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The Use and Abuse of Depreciation

By John H. Murdoch, Jr.

READING and thinking about depreciation during the last few years have convinced the author that too many water works men are trying to do post graduate courses in the subject without first mastering the grade school work. To clarify his own thinking, the author went back to the ABC's and studied the course; and because he found such a study valuable, he now offers some comment on those elementary matters in the hope that they may prove helpful to others.

Every paper on depreciation seems to begin with a definition of the word, and to be in fashion, this one must, at least, appear to follow the practice. Here, however, the formal definition will follow some preliminary development designed to show the nature of depreciation.

When a company purchases a fire insurance policy having a term of five years, it makes an investment in future protection. Money paid for insurance is an operating expense and the money paid for the particular insurance is expense prepaid for five years. The cost of the policy is carried in the balance sheet of the company as an asset in an account which may be called Prepaid Insurance. This item is a prepayment of operating expense and is gradually reduced as the term of the policy expires. As time passes, each operating expense

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account for the current periods reflects a portion of this total expenditure and the item of prepaid insurance on the asset side of the balance sheet is correspondingly reduced, until at the end of five years it is entirely depleted. The asset representing the money cost of the prepaid insurance is reduced as current operations have reduced its value. In the same way, the money cost of chemicals which are bought in bulk and stored for future use is carried on the asset side of the balance sheet as part of Operating Materials and Supplies. The amount is reduced as the chemicals are used in operations; and the cost of the chemicals used in each accounting period appears as an operating expense in the current operating accounts. The original cost of the bulk purchase recorded in Operating Materials and Supplies as an asset is essentially prepaid expense and so must be written down as the chemicals are used.

In the same way the cost of a boiler is recorded on the asset side of the balance sheet; and, since from its nature and from the regulations of insurance carriers and state inspectors, we know that the boiler will have a service capacity which will be exhausted at the end of a fixed number of years, we recognize that the cost of the boiler is essentially an item of prepaid expense and therefore must be written down over the years by amounts included in operating expenses. When we consider the matter we may see that the cost of buildings, machinery and of all assets which are consumed, worn out or displaced because of service, are all items of prepaid expense recorded on the asset side of the balance sheet, and that, because they are prepaid expense items, they should be reduced by charges to operating expenses equitably distributed over the periods during which they serve.

Service Capacity Concept

The money which was paid for the acquisition of the asset was not paid for the items of property, but for their capacity to render service—their "service capacity." In utility practice, the service capacity of a plant item means, at any time, the remaining economic usefulness of the plant item for the utility as used and useful property. Wear and tear, obsolescence, governmental orders, exhaustion, consumption—anything which reduces the remaining possible efficient service content or the ability of the item to render efficient service—reduce the service capacity of the item of property affected. The cost of such service capacity, being prepaid expense, must be

apportioned to the periods benefited, through the inclusion, in operating expenses of the periods, of the portion of the original total cost fairly assignable to each such period. As the original cost of this service capacity is written off through operating expenses, the asset is reduced on the balance sheet.

In utility accounting for fixed capital, however, it is not customary to reduce the asset account directly until the property is actually retired from service, but to increase a reserve account, sometimes called "Accrued Depreciation Reserve," by periodic amounts corresponding with the portion of the original cost charged to operations during the period. These periodic amounts are recorded in an operating expense account, sometimes called "Depreciation Expense." The periodic amounts are intended to write off the original cost of the item of prepaid expense, representing service capacity, by the time that the service capacity is exhausted. When the property item is retired, its original cost is deducted from both the Fixed Capital account, in which it had been entered, and the Accrued Depreciation Reserve account. The result is that, at any time, the balance in the Accrued Depreciation Reserve account is equal to the amount of prepaid expense in fixed capital which has been amortized through operating expenses, but for which the corresponding fixed capital property item has not yet been retired from service. The portion of prepaid expense recorded in the fixed capital asset accounts, and which has not yet been amortized through operating expenses, is equal to the difference between the balance in the fixed capital asset account and the balance in the Accrued Depreciation Reserve account.

Definition of Depreciation

From this it appears that depreciation is the loss in service capacity of plant items which, from their nature, are prepaid expense. A definition of depreciation which is generally accepted today in utility practice is:

Depreciation, as applied to depreciable utility plant, means the loss in service value, not restored by current maintenance, incurred in connection with the consumption or prospective retirement of utility plant, in the course of service, from causes which are known to be in current operation and against which the utility is not protected by insurance.

It seems to be generally agreed now that the words "service value" are the equivalent of service capacity, and, as previously mentioned,

service capacity means, the remaining economic usefulness of a plant item, at any time in its life, for the utility, as used and useful property. Note also the phrase: "from causes which are known to be in current operation." The idea expressed in those words was incorporated in the standard definition of depreciation after Mr. Justice Brandeis, a great lawyer and a great accountant, had pointed out the impropriety of recording depreciation reflecting accruals for contingent losses which might, in the future, be caused by forces conjured up in the mind and not known to be in current operation and to be affecting the property in question. The idea is essential to the definition as, otherwise, depreciation would, in extent, be limited only by the limits of a diseased imagination.

It is clear at this point that depreciation is actually loss in service capacity, a loss brought about by the interplay of many forces, including wear and tear, decay, action of the elements, inadequacy, obsolescence, changes in the art, changes in demand, and requirements of public authorities. The extent of the loss in service capacity is a condition of the fixed capital and is capable of determination by the same types of investigation, study and weighing of evidence as are applied in the determination of other questions of fact. The extent of the loss in service capacity may be expressed in dollars, but service capacity is a physical, as distinguished from a financial, fact; so that its loss, while expressed in dollars, must be determined on a physical basis.

Nature of Depreciation Accounts

If the periodic charges to operating expenses in the Depreciation Expense account have accurately reflected the extent to which the fixed capital assets have been used up in service during the various periods, then the balance in the Accrued Depreciation Reserve account will be the measure of the loss in service capacity suffered by the assets which are still recorded in Fixed Capital. If there is not this accurate reflection, the Accrued Depreciation Reserve account will reflect, but will *merely reflect*, the extent to which Prepaid Expense items in Fixed Capital have been written off through operating accounts. In either case, the balance in the Accrued Depreciation Reserve will reveal facts, but the facts revealed will be different. In the one case, the fact will be the physical fact of actual loss in service capacity expressed in dollars, while in the second case the fact will be the financial one of the extent of the amortization of prepaid

expense. A method of calculating the operating expense item of Depreciation Expense may be perfectly sound as a financial method of amortizing prepaid expense recorded in Fixed Capital and unsound as a method for determining the physical fact of actual loss in service capacity.

Assume for a moment that the balance in the Accrued Depreciation Reserve account does actually reflect not only the extent of amortization of prepaid expense, but also the extent of actual loss of service capacity existing in fixed capital assets; then the Accrued Depreciation Reserve account may aptly be likened to the hole in the doughnut. The true remaining asset is the doughnut with the hole as it exists. This Accrued Depreciation Reserve is clearly not an asset, but a hole in an asset—a deduction from an asset. The reserve, when so considered, is clearly not a source of funds for replacements. The funds come from retained expenses, not from the reserve.

Adequate charges for depreciation expense have the effect of retaining, in the business, funds which might otherwise be paid out in dividends. The funds so retained represent capital available for financing property replacements or additions, retirement of debt, or other proper corporate purpose. It is usual in utility practice to invest such funds in property and plant, as almost all utilities are constantly in need of new funds for fixed capital.

Determination of Rate Base

Let us assume that a utility's rates will be based on some dollar figure, less accrued depreciation; and to avoid discussion and qualifications, let us assume at this point, and at this point only, that original cost less accrued depreciation based on cost is equal to present fair value and is the rate base. Let us assume, also, that throughout the entire history of the utility, construction and material costs remain uniform, and that the balance in the Accrued Depreciation Reserve account will be considered at all times to represent actual loss in service capacity. Further, let us assume, what would be the fact, that the funds retained in the business through charges to Depreciation Expense are invested in the plant.

Then, the following is a statement, although very much simplified by the omission of compensating side steps, of what would occur.

The Accrued Depreciation Reserve is added to each year by the amount of the Annual Depreciation Expense and is decreased by the actual retirements during the year. On the other hand, the

Fixed Capital asset account is decreased each year by the same dollars of actual retirements and is added to by the same dollars in funds retained in the business through depreciation expense charges, invested in fixed capital. Both fixed capital assets and accrued depreciation expense will be increased each year by the same net amount, if no new capital be added. The net amount of fixed capital assets less accrued depreciation reserve remains constant and that net is the rate base of the utility.

Variation of Service Rates With Depreciation Expense

It is axiomatic that utility rates must be sufficient to cover the entire cost of service and that the entire cost of service includes all operating expenses, taxes, and a fair return on a fair rate base. It has been seen that the rate base is not reduced by the deduction of accrued depreciation, if we take the long range viewpoint. Assuming, then, that taxes and all operating expenses, except depreciation expense, are fixed, it is evident that the higher the annual depreciation expense, the higher the service rates of the utility must be. A utility with a plant of such a nature that it suffers no loss of service capacity, and consequently has no depreciation expense, obviously can render service more cheaply, other things being equal, than a competing utility which must meet an annual depreciation expense.

To discover the effect of overestimating depreciation, we may take a simple example. A plant may be assumed to have an original cost of $100,000 and a rate base each year equal to $100,000, less the accrued depreciation reserve. Also, it may be assumed that its rates are adjusted each year to that basis, and that the particular plant is so peculiarly constructed and situated that there are no additions to plant and that all replacements are made at one time, when the original plant is retired as a unit. In such a case, depreciation expense funds could not be reinvested in the plant until the entire plant was ready to be retired and replaced which would take place at the end of twenty years.

When the plant was first built, the regulatory body in charge ordered straight-line depreciation expense applied and ordered that the assumed life should be 10 yr. The depreciation expense would then be $10,000 per year for 10 yr. and a 6 per cent return on the diminishing rate base would start at $6,000 per year and go down to $600 in the tenth year, a reduction of $600 each year. The total for annual return and depreciation would average $13,300 per year for 10 yr.

But the plant remains in service for another 10 yr., although a depreciation reserve of 100 per cent has been built up in the first 10 yr. of its life. The customers of the next 10 yr. may ride free of return on rate base and of depreciation expense, because the rate base was to be cost less the depreciation reserve. If the assumed life had originally been fixed at 20 yr., the annual depreciation expense would have been $5,000 per year, and the 6 per cent return on the base would have varied from $6,000 to $300, with annual drops of $300. In case of a 20-year assumed life, however, the total for the annual return on rate base plus the depreciation expense during the first 10 yr. would average $9,650 against an average of $13,300 when a 10-year life was assumed.

It appears, then, that while the customers in the last 10 yr. ride free of return on rate base and of depreciation expense when a 10-year life is assumed, it is because the customers in the first 10 yr. paid far more for their service than their fair share of the total costs.

Like all estimates of the future, the estimating of depreciation expense cannot be exact. Errors will be made and will have to be adjusted, but that method of estimating should be employed which is least apt to produce serious errors and which will in theory come closest to actual physical and economic facts. In saying this the author assumes that everyone wants to have depreciation reflect, as nearly as possible, such physical and economic facts.

Age-Life Methods of Depreciation

By examining some elementary facts and principles, the author wishes to discover just how firm a foundation is laid for age-life depreciation as the sole method which should be employed.

By the term "age-life depreciation," is meant any method of calculating accrued or annual depreciation, based on the assumption or calculation of either a total life expectancy or a remaining life expectancy for the physical property of a utility. Included among such methods are: straight-line, sinking-fund, compound-interest, annuity and remaining-life depreciation and any and all combinations or modifications. All rest on the theory that time is a function of depreciation. By that is meant that the advocates of age-life depreciation as the universal method believe that for each unit of time in the life of a plant item, there is a corresponding increase in loss of service capacity.

All of the age-life depreciation methods, if correctly applied, if applied consistently to both annual and accrued, and if applied

throughout the entire life history of a utility or with corrections to compensate for past under- or over-accruals will correctly amortize the prepaid expense recorded as a part of fixed capital on the asset side of the balance sheet. It must be borne in mind, however, that a shifting from one method to another may work injustice and bring unsound results, and in attempting to compensate for these shifts of method, injustice may be done to either past or future customers.

It must be remembered, too, that the different methods of age-life depreciation do not all equally approximate the physical facts of actual loss of service capacity.

Variations in Computations by Age-Life Methods

If the various age-life methods in common use were all equally efficient in approximating, at all periods of a life cycle, the actual physical facts of loss in service capacity, there would necessarily be but minor spreads in the results of computations by the various methods. This is far from being the fact. Apply four different methods to calculate the annual depreciation expense and the accrued depreciation on a unit of 10-inch cast-iron pipe costing $1,000, still in service and good standing in its community at the end of 25 yr. service, and having an assumed life of 50 yr., and widely divergent results will be obtained. On straight-line calculation, the accrued depreciation is $500 and annual depreciation expense is $20; on a 2-per cent compound-interest method, accrued is $378.69, and annual expense is $19.39; on a 4-per cent compound-interest method, accrued is $272.78, annual expense, $17.46; on 6-per cent compound-interest method, accrued is $188.73, annual expense is $14.76. By varying the method and the assumed interest rate to be earned on accumulations from 0 per cent in straight-line depreciation to 6 per cent, but keeping the same total life assumption, a result for accrued depreciation where the highest rate is 2.64 times as large as the lowest, and for annual expense where the highest is 1.35 times the lowest, is obtained. While all four methods are mathematically sound for a calculation of capital amortization during the assumed life, since they vary so widely, they cannot be equally sound as a method of finding actual loss of service capacity.

It must be remembered that the unit of pipe in question is still in service and that the assumption of a total life of 50 yr. was made when the pipe was installed 25 yr. previously. If one estimator chose to assume a total life of 50 yr. for the pipe, another chose to assume a

total life for the same pipe of 75 yr., and a third chose to assume 100 yr., and each estimator, at the end of 25 yr., calculated the accrued depreciation at that time and the annual expense for depreciation for that year, using the four sample methods—straight-line, 2-per cent compound-interest, 4-per cent compound-interest and 6-per cent compound-interest—the variations in the results would be fantastic. The highest accrued depreciation would be $500 and the lowest would be $9.73; the highest would be 50.6 times the lowest. The highest calculation of annual depreciation expense would be $20 and the lowest would be $0.76; the highest, approximately 25 times the lowest. All of the methods used would correctly amortize the capital in the assumed number of years of total life, but some or all of the methods or assumptions must be weird if they are to be used to determine actual loss in service value.

Human nature being what it is, the more funds which are available to management through the retention in the business of funds representing depreciation expense, the more funds will be expended in premature replacements and in gold-plating the plant.

Need for Consistency in an Ideal Method

The author should like to be ahead of logical development in stating here his belief that any method used to compute annual depreciation expense or accrued depreciation should be applied consistently to both. The injustice and impropriety of any other course has often been pointed out. On the other hand, he does not believe that the dollar figures used for accrued and annual depreciation for accounting need be used for rate-making. So long as rates are based on other than original cost, accrued depreciation must in fairness be deducted in the same dollar values as are used in other elements of the present fair value calculation. Since all seem to agree that annual depreciation expense should be consistent with accrued depreciation, it follows necessarily that for rate-making, annual depreciation expense should be calculated in the same sized dollars that are used in calculating accrued depreciation.

Basis for Age-Life Depreciation

After this digression, we may return to a consideration of the scientific and factual basis for age-life depreciation. All age-life methods are based on the assumption that the passage of time has some causal relationship to the loss in service capacity of plant items.

To estimate the length of time within which total exhaustion or loss of service capacity will occur, the advocates of age-life depreciation make use of assumed average lives and bolster their statements as to the soundness of their methods by references to the practices of life insurance companies. These matters are discussed only because they have been touched upon by age-life depreciation advocates in formal reports and court briefs, in the course of which unsound statements have been made.

Law of Probability

Look first at the fundamentals of the law of probabilities. Examine it by example and not by formal statement, and follow it through its applications to life insurance and annuities.

If a person tosses a coin in the air and bets that it will come up heads, he stands an even chance of winning or losing. He may continue to toss and to bet, and as to each bet, he still has a fifty-fifty chance, but no more than a fifty-fifty chance. If, however, he bets that out of 1,000,000 throws, heads will come up not less than 470,000 times nor more than 520,000 times, his chances of winning are so infinitely greater that any one would be a fool and he would be a knave for making the bet. It would be no gamble at all.

This illustration, of what every gambler knows, is called to mind because the principle applies to life insurance. The life insurance company can calculate, by applying the law of probabilities to actual mortality tables of similar groups, what number of persons out of a very large group aged twenty years will die in each succeeding year. The calculations are based on the assumption that in a homogeneous population, the life experience of a random sample of sufficient size will fairly represent the experience to be expected of any other sample of at least equal size drawn from the same population. Note that the experience is drawn from a large group and is applied to a group of at least equal size. No attempt is made to calculate the life expectancy of an individual or small group of individuals. No reputable doctor, after a physical examination of a normal individual and a study of a mortality table, showing the life experience of a large group of similar individuals, would undertake to predict the life of the individual just examined. All that such a doctor could say would be that the individual examined appeared physically to belong properly in the same group as others of his attained age. A life insurance policy or an annuity issued to one and only one individual

or to a small group only would be a mere gambling contract and would be unenforceable as such. It would be just as much of a gamble as a bet on one flip of a coin. On the other hand, when a company in the business issues policies on large groups of individuals and insures each individual as an independent unit and bases its rates for such policies on the law of probabilities, it assumes practically no risk, and the policies are valid enforceable business contracts.

Gompertz-Makeham Formula

In this same connection, another point must be developed. Life insurance companies in their studies make use of a formula known as the Gompertz-Makeham formula, developed by mathematicians working with the law of probabilities. The formula is designed to make possible the working out of mortality curves for human beings where no mortality curves based on actual lives completed are available. In its application, several assumptions must be made, one being a definite age assumed for death. Some insurance companies assume this age to be eighty-five, others, a higher age. The ultimate limits of human life are so well fixed by the history of millions of lives that the assumed age for certain death will tally very closely with experience. The number of individuals exceeding that ultimate age will be so small as to be meaningless in a calculation of a large group. The formula also assumes "the average exhaustion of man's power to avoid death to be such that at the end of equal infinitely small intervals of time, he lost equal portions of his remaining power to oppose destruction which he had at the commencement of these intervals." That was the Gompertz part of the formula and to it Makeham added an element to represent death due to chance, without previous disposition to death or deterioration. It is found that when the constants in the formula are taken from actual experience tables, the formula produces a curve which follows closely an actual mortality curve. We know from ages of observation that while natural death is a late development in biological history, human death does appear to be certain to come, and that the vast majority do die before reaching the age of one hundred years. We also know that all human life does pass through well marked stages, and, therefore, Gompertz's fundamental assumption seems to be sound. The fact that results of the application of the assumption closely follow known facts tends to show that the gradual loss of the power

of resistance with the passage of time has some bearing on the time of ultimate death. In other words, in human beings, time is a function of physical decay. All that Makeham did was to add a factor to bring the element of chance into the formula. We know that in human experience such chance of accidental death does play but a small part, and that most deaths are due to the gradual loss of power to resist destruction. As will be pointed out later, this is not true of most of the physical property of a water utility, for in that application, there is no evidence that time is a function of physical decay.

In working out their rates, the insurance companies have studies of millions of human lives, classified and reclassified, revised and re-revised, with changes of conditions. Those rates are based not on average lives, but on the assumption that out of the large group which they cover at each age, a closely calculated number will die during each succeeding year. Two elements are needed to make the business sound: first, experience tables, showing the actual results of the forces assumed by Gompertz and Makeham; and second, large groups to be covered in each age division, so that by the law of probability, no risk will be assumed in the aggregate.

Unsound Application of Insurance Laws to Depreciation

In checking age-life depreciation of physical property against these elementary facts and principles, several questions arise.

First, do the properties of utilities have large enough groups of items to make the risks assumed negligible by the law of probabilities? In this connection it must be remembered that, in depreciation, the group of customers assumes the position of an insurance company which agrees to pay annuities. The customer group is to pay to the utility such an annuity as will amortize the prepaid expense in the fixed capital asset accounts during the life of the property. The customer group pays the annuities and the shorter it estimates the life of the property to be, the higher the annuity must be. For that reason, its estimates must be sound. Are they sound in age-life depreciation?

Most groups of customers of a water company will be paying an annuity on one or a very few reservoirs; on one or very few filter plants; on one or very few pumping stations; on one or very few pumps of each type. Those are the facts, and since they are the facts, where is the justification for applying insurance company

annuity principles to these groups of property? There is no such justification because the groups are too small. Even if, for such types of property, we had accurate and voluminous mortality tables, and even if, for them, it were true—which it is not—that time was a function of depreciation, it would still be unsound to apply the age-life depreciation figures worked out from such mortality tables to items of property in which the risk could not be spread because of the lack of large numbers of identical units in the property being studied. The application to such properties of insurance company annuity practice puts the customer group in a class with gamblers and not business men. So far as size of samples, with consequent spreading of the risk, is concerned, and to that extent only, insurance principles would apply to meters, service lines, mains and valves.

Lack of Mortality Tables for Water Utility Property

One prime objection to the use of mortality tables in estimating depreciation is that the data required are not available and at the best cannot be made available for many years. For the construction of a mortality table for any one type of water utility property, such as 10-inch cast-iron tar-coated mains, complete data would have to be available as to the units of such mains installed during each year and as to the year, if ever, in which each of such identified units was retired from service. From such data, and only from such data, can unit service years be learned, and the average life expectancy of new main units be calculated. Only from such complete data can average life expectancy be distinguished from the very different thing, the median year, which is the year in which half of the units had passed from service. Only from such complete data can average life expectancy be distinguished from the mode year with which it is often confused. The mode year is the year of life of a group of units in which more units are retired from service than in any other year. Use of this year as the assumed total life ignores the fact the majority of the units may remain in service far beyond that time. It is a fact that many assumed life estimates used in depreciation studies are equal to the mode year and are not based even on average life expectancies, which would be more nearly but still definitely *not* sound.

Even if the data were available and were worked into a scientific mortality table for any plant, such a table would not prove that retirements in the past were due to the passage of time. The mere

record that certain retirements did take place in time in the past is not proof that those retirements were caused by the passage of time, so the passage of time cannot be used to measure depreciation for all property types. It must be remembered that mortality tables are a sound basis for estimating the life expectancies of large groups of individual human beings because of the sound assumption made by Gompertz that man's power to avoid death is reduced with the passage of each unit of time, and because most human deaths are due to this gradual loss of power to resist destruction. Contrary to these essential facts of human mortality, a relatively very small bulk of water utility property suffers service death by reason of the gradual reduction, with the passage of time, of its power to resist destruction. A very small part of a water utility plant is ever retired due to decay, disintegration, or wear and tear. Most such retirements certainly as measured in dollar volume and probably in numbers of units, are caused by inadequacy, obsoleteness or the action of public authorities. These influences may just as well come into force in the tenth as in the twentieth year of the life of the plant unit. They do not progress with time because they happen independently of the passage or accumulation of time. That means that, contrary to human mortality experience, most retirements of physical property in a water utility are due to chance and the interplay of a number of influences which, while acting in the stream of time, cannot be measured in their cumulative effect by the passage of time. The bulk of the deaths of water utility physical property is caused by the type of influence corresponding in human mortality data to the element of chance added to the formula by Makeham.

Time Not a Function of Depreciation

So far as most water works physical property is concerned, time cannot be proved to be a function of depreciation. That being so, the only basis for the application of life experience mortality table technique to such property is lacking. With changes in managerial policy, with change in rate of growth of population served, with change in the tempo of invention, with change in materials installed, the experience of past retirements becomes of less and less significance. There is less chance of retirement of small sized cast-iron pipe now, with the development of the sound practice of paralleling mains, than there was before that practice developed. There is less chance of retirement of tar-coated or cement-lined pipe than there

was of the retirement of uncoated pipe. There is less chance now of pipe retirements than there was five years ago because pipe can now be cleaned and cement-lined in place for about one-third of the cost of a new main; and can be rendered more efficient than new uncoated pipe. As pumping units and boilers and motors have advanced in efficiency, the chances of further advances in design and efficiency have been progressively reduced, so that the chances of future retirements of units now in service, and efficient by present standards, is much less than that which applied to old units. With the advance in the arts of water treatment and purification and of the programs of the states for the prevention of the contamination of natural water sources, the chances of the abandonment of present sources of supply are less than a study of the past alone would indicate.

It is submitted that until a relationship of cause and effect can be established between the passage of time and the actual loss in service capacity of physical property, due to all causes known to be in operation, age-life depreciation should not be recognized as applicable to all types of property as the standard method of calculating depreciation.

Depreciation Based on Actual Conditions

Before proceeding, the author wishes to repeat that he believes accrued depreciation should reflect loss in service capacity from whatever causes are known to be in operation and that depreciation expense should be estimated consistently with accrued. Neither the utility nor the consumers should be permitted to play both ends against the middle. He believes that, fairly applied, depreciation, based on a study of actual conditions and the application of proper weight to all factors known to be in operation, can be and has been worked out. Such depreciation studies should be fairly considered, but can not be so long as commissions shut their eyes and ears to the shortcomings of age-life depreciation and accuse all advocates of other systems of being unscientific and unfair because some companies were both in the past.

In the remaining portion of this paper, thought will be given to methods of estimating both accrued and annual depreciation based on a study of known conditions. These methods are advocated because they are based on the idea that depreciation is fact relating to the condition and economic usefulness of utility property, and that this fact is determinable by competent appraisers from an

examination of all known relevant circumstances. These methods do not require the making of the assumption, as to all physical property, that age is a function or measure of loss of service capacity. They are based in part on the sound assumption that a competent engineer can determine the condition and the remaining economic usefulness of a piece of property without knowing how old it is. Before going further, the author wishes to state that, though the methods here advocated will almost always indicate an amount for annual depreciation expense which is less than would be indicated by a resort to the age-life methods, and that though the depreciation expense will be less than that indicated by the other methods, he believes it still to be adequate.

Depreciation Methods Vary With Type of Property

It is agreed that depreciation is loss of service capacity. Depreciation is, then, a fact to be determined, as other facts are determined, by an examination of all the evidence. As to the fact of loss of service capacity actually existing in a unit or group of units, complex and inter-connected and acted upon by many forces, it is idle to assume that any one method or formula can be applied to all the units or groups of units. One method will be sound as to some and unsound as to others. The light bulb about to burn out and fail may look good, but the evidence in the records, showing that it has been burning approximately the total number of hours for which its elements will live, will indicate that the bulb has lost practically its entire service capacity. It should be depreciated by an age-life calculation certainly. The same thing is true of boilers. In these and a few similar cases, the physical facts are such that depreciation by the age-life method is sound.

Take another example. A fine slim-bladed, well balanced meat slicer, made of the best modern cutlery steel, is presented for a depreciation study. Its age is unknown, but it is known that invention for hundreds of years has not been able to improve the design. There is no known force tending to make the knife obsolete, but it is very dull. What is its loss in service capacity? It is not as useful as a sharp knife of the same material and design, so it has lost some service capacity. Its loss in capacity may be measured by the cost of making it sharp and by a percentage loss in future capacity to reflect the fact that continued future sharpening will ultimately use up the effective cutting blade. This is not age-life depreciation,

but a depreciation based upon a weighing of physical facts. The appraiser did not need to know the age of the knife or how many years it had yet to live.

Take the case of a lead pencil. It may be a perfectly efficient writing instrument when its writing length is half used up, but at that point it is certainly 50 per cent depreciated because its remaining economic usefulness is only 50 per cent of what it was when the pencil was new. Its service capacity is 50 per cent used up or lost. The depreciation is, however, determined by inspection. The age of the pencil need not be known and no total life needs to be assumed. Its depreciation is a factual condition revealed by inspection.

Determination of the condition of buried pipe lines by engineering studies is neither difficult nor unusual; and the results obtained by competent fair-minded engineers working independently of each other are so closely in agreement that the results must be sound.

Obsoleteness is a fact capable of determination. It may be partial or it may be complete, but, for every type of water works property, an honest competent engineering appraiser can determine the extent of obsoleteness existing. He weighs all known factors tending to show obsoleteness. He compares operating costs, capital costs, reliability, flexibility, established governmental policies as to grade crossing eliminations, street widening, hump removals—all forces which can be called to his attention as being in operation—and giving them all their proper weight, he gets a sound factual determination of the loss in service capacity due to obsoleteness, inadequacy and the actions of public authorities.

Similar studies of all other forces known to be in operation and affecting the utility property are carried out, and as a result of these studies, the appraiser is able to determine the amount of loss in service capacity of the property. He determines it as a fact applicable to the existing physical property.

Elements of Total Depreciation

Total depreciation of any utility property consists of two elements: (1) the completed depreciation which is the amount of all the property of the company which has, in the past, ceased to be useful and been retired from service and taken out of the fixed capital accounts; (2) the depreciation or loss of service capacity actually existing, as of any date, in property either still in service or still retained in the fixed capital accounts. Both elements of depreciation

must be considered if sound and conservative results are to be obtained in calculating the proper amount to be set aside annually as depreciation expense. Depreciation expense and accrued depreciation both based on actual loss in service capacity must be determined consistently with each other if fairness to all is to be achieved.

Annual depreciation expense is the loss in service capacity suffered during the year. If the actual loss in service capacity is determined by study at the end of last year and if a similar determination be made at the end of this year, both as applied to property still in the Fixed Capital account, then the annual depreciation expense for this year is the increase in the dollars representing loss in service capacity during the year, plus the amount of retirements during the year.

In the same way we can find the total depreciation during the entire life history of the utility. At the beginning of that life history, the loss of service capacity in the new plant was zero, and from that fact it follows that the loss in service capacity in existing property through all the years of the plant life is simply the amount, in dollars, representing loss in service capacity in existing plant as of this date. To get total depreciation we must add to this figure all retirements through all the years.

An Actual Depreciation Method

If existing property, actual loss in service capacity, and all retired property are all expressed in dollars of a uniform value, and if all property existing and retired be weighted for its actual years in service and averaged over the total completed years of service of the entire property, we then get the average investment in existing property and the average investment in abandoned and retired property. Since total depreciation, consisting of actual loss in service capacity of existing property, plus total retirements in the past are both expressed in the same dollar values, this total, divided by the total age of the property, will give the average annual amount of depreciation or loss in service capacity. This last figure of average annual amount of depreciation, divided by the average investment in existing and abandoned property, will give the average annual rate of depreciation expressed in percentage. The percentage, applied to the undepreciated existing property, is the calculated amount to be set up for the immediate future for annual depreciation expense.

Annual depreciation expense so computed is based on exactly the same data as those used in determining actual loss in service capacity.

The history of all retirements in the past is given its exact weight in estimating expense in the future. Obsolescence is given full weight in both calculations. Obsolete property is included in total loss of service capacity, either by inclusion in retirements or by inclusion in the engineering study of existing property, or both. All obsolete property is thereby properly deducted from a rate base and the company forecasts its depreciation expense on the same basis. All of the depreciation, past, present and future, is based on facts revealed by a study of all the elements known to have brought about loss in service capacity of this particular company.

Comparison With Present Methods

It is probable that, if anything, an annual depreciation expense so determined from a study of the past and present of a water company will be found to be somewhat higher than will be needed for the indefinite future. This is for the reason that by including, as a factor, all past retirements, it assumes that future depreciation expense will follow the history of the past. Since each step of progress in invention brings perfection nearer, and since the present trend in water works progress is in the direction of a prolongation of the service life of property now in service, rather than in the direction of a shortening of that life, it appears that an annual depreciation expense for the future, based in part on a history of past retirements of property, may be on the conservative side. It may be found to be higher than is necessary.

Unless we are all ready to abandon the idea of depreciation being a loss in service capacity and unless we are ready to accept depreciation as being merely the mathematical amortization of prepaid expense, without reference to physical and economic facts, we should adopt those methods for determining the extent of the loss which bring results most nearly conforming with the facts actually existing. The author has argued against age-life depreciation because he believes it to be unsound in theory, unscientific in application, and because he believes its use results in excessive allowances for depreciation expense.

Property Records and Valuation

By Reeves Newsom

GENERALLY speaking, municipal water works plants have not in the past been greatly interested in the subject of valuation, nor have they been greatly concerned about the accurate recording on their books of all items of property or the proper accounting for the retirement of old and substitution of new elements of plant. Consequently, sufficient thought has not always been given to the making of records of many physical changes that have taken place and to the accounting for the cost thereof.

In the past few years, through the work of the Accounting Division of the Association, a greater consciousness of the desirability of keeping proper records has been developing. The completion of the *Manual of Water Works Accounting*, which provides a valuable guide for those who are interested, has given this movement great impetus.

At the same time there has been a spread in the movement to place municipal plants under the jurisdiction of state public service commissions, particularly with regard to rates and the issuing of securities. Due to the general extension of central control by government and state agencies it is logical to expect that the water works business, even though largely municipally owned, will, in an increasing number of states, find itself a regulated industry.

As this happens, water departments are going to be faced with some of the problems now confronting the private water companies; and in trying to meet those problems they will find themselves handicapped by one thing common to nearly all water works systems —lack of adequate records of what has transpired in the past. If departments wait until they are called upon to furnish records it

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will be too late to start keeping them; and their lack may be made up by the arbitrary assumptions of people outside the department devoid of knowledge of local conditions and of any particular local interest.

One of the early types of regulation to be expected is that of rates to be charged to customers outside the city limits or to other municipalities. It is becoming common practice for an increased charge to be made outside the corporate limits of the municipality owning the water system. The last revision of the Public Service Law of Pennsylvania provides for the regulation of municipal plants in that respect and, undoubtedly, represents a first step toward the more complete regulation now in force in Maine, West Virginia, Indiana and Wisconsin. The author is now engaged in preparing the evidence to be presented by the City of Ottawa, Canada, in the first case of a similar kind before the Ontario Municipal Commission, which has recently been granted such jurisdiction over the municipal plants in that province.

When regulation arrives, the questions of what the plant consists of, what it is worth and at what rate it is wearing out are to be met.

Investment Records

In many cases the book figures representing the plant investment are far from correct. It has been common practice for water plants to be improved and extended with money from two sources: the sale of bonds and water revenue not required for operation. Over a period of a half century the improvements made and charged to operating expense can amount to a substantial percentage of the plant in service. This practice has been common in private plants as well as municipal departments and, as the former came under regulation in the past, a great deal of work was necessary to find out the facts regarding the transactions of early days. In many cases it was impossible to do so.

Furthermore, in private plants in the early days, and in many municipal plants today, the substitution of new items of plant for those which have to be replaced, and the abandonment of plant no longer useful, was and is not properly reflected on the books. The old items may not be deducted from the plant account and the new items may be charged to maintenance. As a result, the book figures may not come within the proverbial "row of apple trees" of representing the investment in the plant.

There is also an increase in the practice of the sale of water revenue bonds, entirely divorced from the city's general credit, to finance improvements. With the increased problems of raising money, with which this country and all its political subdivisions will be faced in the future due to defense requirements on top of heavy present indebtedness, it is reasonable to expect that in more states, laws will be passed to enable water departments to finance their needs without affecting the borrowing capacity of the city involved.

When revenue bonds are to be sold against the water plant and its earnings, the question of the equity behind such bonds is of moment; so the value of the plant must be determined. Whether for this purpose or for rate purposes, the engineer who is to evaluate the plant must have, as the basis of his appraisal, an inventory which is sufficiently accurate so that he can substantiate, under all circumstances, his statement that it represents the actual property used and useful in the system's operation. He cannot guess as to the location of dead ends of mains, as to the existence of valves with covered boxes, as to whether services are made with goosenecks or straight connections, as to the size of hydrant laterals and valves, merely from the size of the hydrant barrels or as to the weight of unusual specials and flanged piping buried in a mass of connections and under some pumping or filter structure subsequently constructed. In addition to the measuring, scaling and counting of things properly recorded, much time and money is usually spent in locating, digging up and ascertaining the facts about things not recorded—perhaps known only to some old employee no longer available. If, as a matter of routine, all such data are gathered and made part of some plan, card or other record, the work of appraising a water plant would be greatly simplified.

Inventories of Physical Property

In connection with making an inventory, it is necessary to decide which items of the plant are no longer used and useful, because it is only on useful property that a system is allowed to earn. In the average case a great many things will be discovered which should have been disposed of and written off the books years before. At the same time, one's enthusiasm for a good cleanup of such a situation should not lead to the disposition of equipment which could conceivably be used as a reserve in emergencies. In connection with the current problem at Newport News, Va., of suddenly fur-

nishing a much larger amount of water, the manager of that plant and the author have found great usefulness for pumping and booster equipment long since considered out of the operating picture but which, fortunately, had not been dismantled. Unless the ultimate in emergencies can be handled otherwise, available equipment which can run should be kept if the cost of maintaining it in readiness for service is not burdensome.

The physical property comprising the elements of a water works divides itself, for purposes of valuation, into nine principal parts. Forms for permanent records should be set up with this in mind. The divisions are:

Land	Services
Structures	Meters
Purification Equipment	Hydrants
Pumping Equipment	General Equipment

Transmission and Distribution Mains and Accessories

Valuation of Land

Land is not customarily appraised by the engineer making the valuation, but by real estate men qualified by a knowledge of local conditions to appraise the land used by the water plant.

It is necessary, however, for the engineer to furnish to the local appraisers a complete list and proper descriptions of land owned in fee, easements for limited uses and leases. Because, in the average case, the records of real estate owned are very inadequate and badly mixed up, the compilation of these data proves to be a laborious and costly procedure, often out of all proportion to the value of the land relative to the plant as a whole. This could be avoided if water departments and companies would have some one designated to organize and keep these records in spare time. Some field work is usually required to straighten out the conflicts resulting from incomplete and evasive descriptions. These records should not be postponed until the information is actually required, as it is often a difficult and time-consuming process.

Classification by Use

When included in the appraisal, the figures of value are subdivided to cover land used for supply, purification, pumping, transmission and distribution and general use; and the records of holdings should be so tabulated when being compiled.

The data regarding structures should likewise be grouped according to their use, whether for source of supply, pumping, purification, distribution or general. Equalizing reservoirs and standpipes are included in the distribution structures. General structures are subdivided under offices, stores, shop and garage, and miscellaneous structures.

The equipment in a purification plant represents a unit group, but pumping equipment should be classified on the basis of type of power, and further grouped under each station using each type.

Detailed Record of Construction Elements of Structures

In connection with structures of various kinds, details of quantities of the various primary elements involved, including excavation of various types as required, should be obtained from the contractor's, engineers' and architects' records, and should be carefully preserved along with plans, specifications and forms of contract used. Details as to cost, with such breakdown and estimates for payments to contractors as were made, should form part of the permanent record. The cost of work done by department or company employees should be incorporated in the completed record. This latter item is one which often, in the past, has had very little consideration and is another way in which plant costs have crept into operating expenses and form no part of the property account.

Detailed Record of Elements of Equipment

With regard to equipment of all sorts, detailed descriptions of what was purchased, together with a breakdown of the cost into as many elements as possible, as reflected in contract schedules, bids submitted, and estimates for contractor's payments, should be carefully preserved as a record for the future.

Whether the value of the plant is to be based on cost new less depreciation, on original cost, or on both, a true record of what is comprised by the plant must be made available, and information as to actual cost when constructed is extremely helpful. This is particularly true of equipment which is not manufactured today in the form originally installed.

Records of main pipe installations should be kept in considerable detail. The materials used and method of manufacture form logical bases for classifying mains. The footage of pipe installed should be recorded so that the tonnage of pit-cast cast-iron pipe can be ascer-

tained as well as the footage of special process pipe or pipe of materials other than cast iron. Too often pipe of different types cannot be identified as to the streets in which it was laid, because in certain years more than one type was used and only the total of each is known. When retirements of pipe are subsequently made, difficulties will be encountered in adjusting the books unless identification is definite as between types used in various locations.

As a practical matter it is not necessary to know, for valuation purposes, the exact number and type of specials used in every pipe line; so that beyond the needs for knowing the type of branches available at street intersections, no elaborate method of recording specials is needed. They can be determined by a percentage method to the degree of accuracy which their excess value over straight pipe justifies. Of course this is not true of valves. They should be accurately recorded by size, under the various types and manufacturers' names.

Construction Details of Pipe Installations

There is another type of record in connection with laying cast-iron pipe that is rarely made but which should be carefully compiled while construction data are available, because the element of cost involved is substantial. The data referred to cover the yardage of solid rock removed, the footage of trench in which soft rock or very hard earth was encountered, the amount of trench which had to be exceptionally wide for one reason or another, the length of trench in which water was encountered requiring pumping or shoring, the length and character of stream and rail crossings and the amount and type of paving that is cut and replaced. All these things which represent departures from the average conditions should be noted in such a way that the added cost can be earmarked, or estimated at some later date. The cost involved in different types of difficult construction, over and above that for average laying conditions, is often quite sizable.

Furthermore, when pipe is re-laid in out-of-the-ordinary trenches, many of the things encountered the first time are either not present or the degree of effect on cost is materially different. Thus, different parts of the work depreciate at different rates and, in accounting for retirements, some parts of the work would never have to be replaced or done over, as, for instance, the excavation of solid rock.

Records of Services, Meters and Hydrants

The inventory records of services should be grouped under various types of materials used, showing footage by size. Services should be further classified on the basis of the type of connection at the main and at the curb. Valves, stops and boxes can be accounted for either as a part of the respective service or grouped separately by type and size. Here again records should show the data regarding unusual and difficult conditions, encountered during construction in various parts of the city, which result in costs above the average or ordinary.

Meters should be divided between those in service and in stock; and meters in stock should be broken into new and used. Under these divisions they should be grouped by manufacturer, with types and size under each. Meter settings of various kinds are best kept separate, except that, where substantially all settings are inside, the cost of all but the large ones can be recorded in combination with the meter and its fittings. In passing it might be well to note that for accounting purposes, meters are best treated differently than other items of materials and supplies. Because of frequent changes it is best to include all meters, as soon as purchased, as part of the plant account rather than to put them in and out of the materials and supplies account. The extra work involved in doing the latter is not justified.

Hydrants should be recorded according to manufacturer and under each by size of valve, nozzle combination and length of bury. They will, thus, be classified according to the factors by which the cost varies. Hydrant laterals and valves should be recorded as a group and, in connection with the installation, difficult construction costs should be noted.

General equipment records should be divided under the headings of office, transportation, shop, laboratory, and tools and work equipment.

Value of Continuous Records

It is obvious that a lot of information is required as to what a plant consists of, when the time comes to find its value. At the same time, it can be seen how easily the data could be preserved if, with a plan of procedure at hand, the records were made as the construction work progressed. The mere fact that such records

have not been kept in the past is not a good reason for failing to begin doing so now. As partial replacements take place in the future, much of the data needed to complete the records for past construction will come to light.

In many states, private companies are being required to set up continuous property records, and a number of municipal plants are doing likewise. This is a combined engineering and accounting problem. So far as records are available and complete, it is a matter of classifying such records; but in most cases records are missing for early years and often it is impossible to reconcile dollars and units of property, so the engineer must make up an estimated historical cost record for such periods. Continuous property records, when completed, constitute not only a permanent inventory but represent the data, regarding original cost, needed to adjust the books to reflect the total cost of the plant, no matter where the funds came from to build it. Furthermore, data are made available for proper entry of retirements on the books of account, so that the records will continue to be accurate. Revaluation of a plant, from time to time, would be a relatively simple matter with such a record available.

Whether a plant is to be valued on the basis of reproduction cost new less depreciation or whether there is, for determination, merely the problem of a proper annual provision for retirements and replacements, the question of the condition of the plant and the rate at which its various elements are approaching retirement must be met.

Lack of Adequate Basis for Depreciation

Transmission and distribution mains represent the principal element of value in a water works property, sometimes running as high as 80 per cent of the total physical value. As a result of the widespread use of cast-iron pipe in the last seventy-five years, this principal element of plant value is constructed largely of a very long-lived material. A paucity of records of what happens to water mains as communities grow, however, has led to the use of estimates of lives for cast-iron pipes, relatively short as compared to the life of the material itself. This was done on the theory that in the majority of cases something happens at a relatively early age to cause the size of the pipe to become unsuited to the conditions.

A recent factual study which was made and reported upon to the Association by E. H. Aldrich and the author (Jour. A. W. W. A.,

31: 1625 (1939)) has revealed that, generally speaking, the assumptions that have been made in recent years with regard to the lives of cast-iron water mains, 6 in. and larger, are too conservative. The study was made of a city in which an unusual number of factors other than the corrosion of the material used operated to bring about the replacement of water mains. The community had grown rapidly for seventy-five years, varying between a 16 and a 45 per cent increase each decade. In the middle of that period, the source of supply was changed from one end of the system to the other and the pressures were materially increased. In addition, the efforts of the water department to meet the requirements of the National Board of Fire Underwriters had been carried to such a point that, in the latter's last report in 1938, no recommendation for improvement was advanced. Thus, there was found in one plant a very unusual set of circumstances, tending to produce a maximum of replacements of mains, retirements of the type caused by inadequacy. Fortunately, this plant has nearly complete records of the installation and retirement of mains since 1864.

An examination into the facts, thus recorded, reveals that after nearly seventy-five years, the survival of the cast-iron pipe is over 89 per cent for 6-inch, exceeds 90 per cent for 8-inch and is better than 93 per cent for 10-inch and larger. Partial data from a few other cities indicate that even better survival records may be expected in the average case, which indication will be better grounded when additional studies are completed and when additional records are made available.

Records as an Adequate Basis

The determination of the physical condition of the interior of pipes carrying highly corrosive waters is greatly simplified where the operator has kept, properly identified as to location and date of removal, tapping discs, pieces of pipe removed to cut in valves or tees or parts of lengths that have broken. Much of the conflict of opinion regarding the probable future lives of pipe lines would be eliminated if accurate records were kept of the retirements of pipe, and the reasons therefor, and if, over a period of time, progressive tests of the changes in pipe line coefficients were made and the detail costs of main cleaning were kept, relating both to the dates of changes in water treatment, if any have been made.

Experience indicates that, particularly in the case of cast-iron

pipe 6 in. and larger, when items are retired, a substantial part of the material is salvaged and re-used. To determine properly the effect of such salvage upon depreciation, the faithful recording of facts in this regard is required.

Efficiency tests of pumping units, made at regular intervals, will give a much more definite idea, regarding the depreciation of these facilities, than can be gained from a single test made at the time of the appraisal.

If an age-life method of computing depreciation is to be used, the date of installation of each unit of the plant is required in order to determine the average age of different classes of property. The history of the retirements of the elements of the plant that have passed out of use is needed to supplant the engineer's general knowledge of probable service lives. At best, his knowledge is limited, in the case of pipe lines and dams, to what has happened in but a fraction of the total lives of property of those classes. Where good records are kept these data will be available.

Uncertainty of Future Demands Records of Past

The methods of operation that have been followed in the past, even in as relatively stable an industry as the water supply business, are, undoubtedly, becoming outmoded by the changes which are taking place in the world today. It can be anticipated that new demands will have to be met for justification of many of the things that in the past have been done as a matter of course. The raising of funds for water extensions is already in a different category psychologically than before the days of P.W.A. The scope of activity of regulatory bodies of all sorts has been vastly enlarged. Rates and the allocation of charges between domestic and fire service can be expected to be questioned even in municipal plants in the era of high taxes in prospect. Almost certainly some degree of change for water departments may be expected and conceivably it can go beyond anything we now anticipate.

Whether it be an effort to combat undesirable changes or one to take the greatest advantage of desirable ones, the water works plants which will be most successful will be those that can prove their contentions by recorded facts and not merely by the recitations of mental precedents.

While most of the points regarding good records here made have been related to valuation, there are, of course, others which may be

equally important. Not the least is the fact that the keeping of good records insures better operating knowledge and tends to produce more careful attention to supervision.

Good records form the best basis for intelligent future planning and for decisions as to the type of materials and equipment giving the best service under local conditions.

Again, there is the matter of change of personnel resulting from the encroachment of politics upon municipal operation. While this is greatly to be regretted, it must be recognized as a reason why knowledge carried in men's heads cannot be depended upon in lieu of written records.

The accumulation and compilation of adequate records of what you have and what has happened to what you did have should begin today. It is going to be difficult at best, but you are urged to make a start and that promptly.

Efficiency in Managing Water Works Properties

By Leonard N. Thompson

SINCE efficiency in the management of a water department, if accomplished, is best built around or into an ideal organization, it seems necessary first to consider what constitutes an ideal.

Essential to such an organization, though not necessarily in order of their importance, are its governing body, its management, its legal restrictions, its financial structure and, finally, its personnel.

A water board or water committee or whatever form of control the city has over its department, it is generally agreed, should be non-political in character. By that, is not necessarily meant that such a board should not have some representation of elective officials, but rather that all possibility of political control or influence should be held in check—if necessary by charter or statutory safeguards. While for many years the author has been happily associated with a water board of political composition, he still holds the opinion that in the great majority of instances and in the best interests of efficiency, such a board should be composed, at least in part, of appointed membership, with overlapping terms of office and with duties which are confined strictly to the legislative and not administrative.

The financial set-up should not alone protect and safeguard the earnings of the department, but should provide a reasonable means of raising the funds required for the usual and annual capital expenditures and, by law, assure rates which will make the department self-supporting. There does not seem to be any great or essential difference in the method of financing that provides for at least a part of the capital expenditures through a reserve fund created from earnings or by a method which will raise those funds by the bond-issue process, so long as the machinery is workable and sure when

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these monies are needed. Personally, the author does not favor a bonded indebtedness for the financing of comparatively short-lived capital improvements or even those for annually recurring types of capital betterments, such as the purchase of meters, valves or pipe used for the normal annual extensions to the system, unless there exists, by law, standing authority for bond issues equal to the annual capital outlays required. The issuance of annual or nearly annual bond issues which require specific popular approval will tend to break down public confidence in well directed management. Major improvements, however, should be made *only* through specific bond issues, preferably, approved by the voters.

Efficiency Applied to Management and Personnel

These, and like problems of financing, however, are controversial questions which may be answered differently by representatives of the different schools of thought. For most of us, the methods are dictated by existing laws or ordinances, and, since we are dealing in fact and not in theory, most of these conditions are already established; and in the main, no amount of theorizing will change the basic conditions under which we work. With the management and personnel, however, we should be able to do much, and if we lack efficiency in these, the fault must invariably be ours.

Somewhere, the author once read the following statement.

"There is no single item by which a management of a municipal water plant can be judged, as its business affairs differ from those of other public utilities and nearly every other kind of business.

"A water department usually has a monopoly in a community, and because the new uses for its product are so limited, it does little advertising."

In the main, the author takes issue with this opinion, since strict adherence to such a theory certainly cannot be conducive to efficient management. Certainly, this monopoly that your business holds in your town is not, or should not be, any different from that held by any private utility. Often it is no different than that held by any type of private business. Certain it is, also, that municipal ownership is continually being judged by the same standards as are applied to private ownership. Efficiency in the management of a water works is essentially no different from efficiency in the management of any business. The principle of municipal management is, or should be, basically the same as that of private management.

Four Factors of Efficiency

Stated in the simplest terms, and as seen from the consumers' standpoint, efficiency is generally judged on four counts: service, quality, price, and financial status. The consumer is interested in the first three; the stockholders, which in the case of a publicly owned plant are the taxpayers, should be, but seldom are, interested in the last. The consumer's reaction to service, quality and price, may be simply expressed in the term "Good Will." The good will of a business is that intangible something which is not the credit reputation of a company nor its borrowing power, but the feeling of a community toward a company that has learned the secret of being human. Somewhere in such an organization there must be a guiding hand—some one person whose function is essentially necessary. His duties may cover a wide range, but be he in front or behind the scenes, the result of his executive ability is apparent. From his work must be developed corporate as well as individual character.

Necessity of a Competent Staff

Good management requires absolute confidence in department heads. From his early association with a water department, some 28 years ago, the author remembers a certain executive who made it a practice to keep, as far as he could, all important facts and knowledge to himself, in his own personal files, apparently for the purpose of magnifying his own importance before his board and the public. As the department continued to grow, this very practice finally brought about a complete re-organization and with it a new superintendent. It is good practice to train the man under you for your own job as fast as he can or is willing to assume the responsibilities. It will be well to associate yourself with the best minds that you can acquire, as their success will be your success. One must be very careful in the selection of ones associates, but once tried, they should be given all the responsibility that they can handle. Good management of public services, if they are to reach or maintain high status, must command the services of competent employees, and since the element most essential to efficient operation is the organization of a competent staff of employees, to accomplish this, the management should be free, as far as practicable, to select that personnel, and to use every care in its training. Those individuals who can be taught and who will try to understand their respective tasks and to perform

their duties with credit to themselves and to the company must be chosen. Civil service may be the only answer to the elimination of special privileges or political patronage, but like almost any cure, too much application may tend to defeat the very purpose it is designed to meet. The superintendent should, through civil service, encourage and further the idea of career service, but should just as vigorously repel the growing tendency which creates in the employee's mind the thought of protection, cloaked in civil laws, against removal or transfer for any cause. The author is of the opinion that a *good* manager is just as considerate of his employees' rights without the special protection of civil service ordinances.

Employee Relations

Since the attitude of the employee will generally reflect the character of the management, training him, and giving consideration for his complete interest in his work are as essential as his original selection. Employees should not only be made familiar with the rules and be made to understand the reason for every rule so far as practicable, but they should be given every opportunity to learn the rudiments of the work of other employees. For example, a new employee should not be placed in the meter-reading department without first having a thorough instructive course in meter repairing. The same method carried out between other similar positions gives all employees an understanding of the other fellow's problems and leads to greater harmony. It seems to be a human characteristic to consider our own particular job as just a little more difficult, a little more important, than the other fellow's. Acquaintance with and appreciation of his problems will do much to break down misunderstanding, and promote good will among the employees. Another technique which will both relieve monotony and discover new capabilities in the staff is the occasional shifting around of the personnel.

Every consideration should be given to the employee's comfort and pleasure. There is no better way to obtain *esprit de corps* than the occasional bringing together of all the employees and their families. One means of doing this is the provision of means of recreation for use during noon hours and before and after work. Occasional parties and an annual picnic can also be effective.

Interest in the safety of the employees, not alone from the economic standpoint, but for the perfection of their good will and interest,

pays valuable returns. Employees' safety and welfare committees should be encouraged. They are directly beneficial to good management. Other things being equal, the service an employee gives will be in direct proportion, good or bad, to the conditions which are created for him to work under. Harmony within the organization is the first essential to a good public front. General public salesmanship may be the function of administration, but what may be termed "over-the-counter salesmanship" will, day in and day out, achieve the greater results; and this rests largely upon the employees' training. All the public talks presented or the articles written about service will go for naught if the individual consumers, dealt with day after day, are not sold on that service by the particular employee whom they contact. Publicity may emanate from the head of the department, but good will is gained or lost through the employee.

Accounting and Control

The Accounting Division is to be congratulated upon the splendid manual it has published.* Its study and intelligent use will be a big step toward efficient management. To some of the smaller companies, proper and adequate records and methods of accounting may seem needless and expensive, but in the long run they will pay large dividends. Efficient management recognizes the value of accurate records of costs, not only of construction but of normal plant operation. It is not the exclusive function of either the accountant or the engineer. Proper management requires the closest co-operation of both and an understanding by each of the other's point of view. Too much stress cannot be given to the continued close co-operation between the engineering department, where charges arise, and the accounting division, where charges are allocated. Thorough knowledge, by each division, of the basic problems of the other is of immense value to all concerned.

As a good painting is best appreciated from a respectful distance, so should a good manager observe his organization from a proper perspective. Too close attention to detail may lead to the same complications as the curiosity that killed the cat. It is well to remember that department heads probably know as much, and perhaps more, about the details of their particular jobs, as does

* *Manual of Water Works Accounting.* Published jointly by the Municipal Finance Officers Association and the American Water Works Association, 1938.

the superintendent. By all means, a superintendent should keep ahead of his employees; he should be master of the ship and know the direction in which it is going, but he should not try to handle the oars and rudder at the same time.

Proper accounting is not the mere compilation of figures and their transfer to some account, but the preparation of intelligent statistical data for the study of the factors and operations which produce those costs. The proper perspective of the functioning of all departments may be had by a properly established system of daily, weekly and monthly reports, making sure that such reports are concise and illuminative, accurate and standardized. It has been the author's practice, for years, to insist that certain brief statistical reports be laid on his desk periodically, as it has been his experience that the insistence on properly prepared reports not only keeps the management in touch with all phases of the several departments, but also keeps the employee on his mettle. Aside from the discussion of matters of policy, with these reports, one may know fairly accurately the several results obtained.

Plan for Future Improvements

Just as important as the financial policy is a carefully thought out plan for future improvements. It is well to adopt a definite program which you can defend and sell, and to stay close to it. A well thought out program, properly presented to the public, may secure the aid of the community organizations and service clubs to overcome the lack of appreciation of the importance of your water works improvements on the part of certain public officials, who may accept or approve that program on grounds of political expediency only.

Good management dictates that good and sufficient records should be maintained, in order that the superintendent may at all times have an accurate conception of the plant he operates. Proper records and the history of costs on all construction jobs are absolutely necessary. Good maps, filing systems, indexes of gates, mains and hydrants, and blueprints are as important as stock-card records. Accounting records of purchases, prices of materials, contracts, and job costs will pay large dividends. That part of the works below the ground, and which constitutes a great percentage of plant investment, can only be inventoried by reference to complete and accurate records, so if for no other purpose than possible rate cases or future valuation, these records are essential. Good records must be maintained per-

petually. A committee, of which Victor Weir is chairman, published an excellent report on plant records (Jour. A.W.W.A., **32:** 181 (1940)). The author's only caution to the plant manager is a warning to install the simplest possible plan which will serve his particular needs; a multiplicity of records inaccurately or spasmodically kept are as bad as no records at all.

Good Service

Good service means good service crews. A department of any size should maintain both day and night emergency crews, thoroughly familiar with the distribution system and records. This ability to receive emergency calls for 24 hours of the day is good and appreciated service. The St. Paul, Minn., water department has recently installed police radios on all emergency cars, thus enabling the office to reach important crews and foremen almost instantly. It has been the experience of this department that any large break in a water main that will attract the notice of a newspaper reporter will also immediately draw attention to failure to take immediate steps to meet and control such emergencies. The presence of a water department emergency truck at all fires, is also desirable and often necessary.

Customer Relations

Ideas as well as equipment may become obsolete. Almost constant attention is required today to keep abreast of rapidly changing methods and equipment. Whether a plant is small or large, the adoption and use of new and up-to-date equipment and labor saving devices will be valuable. A well equipped laboratory, an office provided with modern accounting and clerical forms and machines, a work crew using modern and efficient methods will, at least, create an atmosphere of efficiency. In like manner, the beautification of the plant and attention to its cleanliness, and supplying the filter attendants and laboratory men with clean and smart uniforms will instill in the customers the idea that care and exactness are taken in supplying their water. No management will ever be long criticized for the expenditure of funds when results are shown.

It is becoming increasingly evident that only by taking the public into confidence can a department expect or ask their support. Absolute frankness in the public discussion of problems will in the end win friends. There is no point in trying either to hide or to evade

difficulties. Public criticism will thrive only on those questions which are not thoroughly understood or which smack of evasion. Boastfulness is obnoxious, but, professionally, water works men have too long hidden behind the cloak of false modesty. In every city of any size it is surprising how many luncheon and service clubs are looking for good speakers. Water works superintendents have for generations averred that they are not orators. It is time that they drop this attitude and do a little verbal advertising by taking advantage of the opportunities presented by the press and radio. If they still insist they cannot talk, they can use a movie machine or a lantern slide machine to good advantage in giving a picture story of the department. It is surprising how much interest can be created in this way. People are glad to hear that there is a story behind the faucet. It is only through a thorough knowledge of the accomplishments and aims of the department that the consumer is able to judge the efficiency of the organization and to measure the value of its services. While these things may seem non-essential to the business of selling water, if, thereby, the confidence and cooperative good will of the community can be cultivated, something of tangible value will have been accomplished.

Sales Techniques

Basically, where is the water business so different from any other business? The methods of salesmanship, which have harped on the cheapness of water, are to be decried. Water at its source is a raw product, but what the water works are selling today is, in effect, a manufactured product—as much so as any highly commercialized item on the market. Industrial life and education today require the same degree of refinement and care as the handling of any food or medicinal product. Demands for purity, clarity, softness and abundance have seen water works engineering pass into a highly specialized field. Experience should indicate to every operator that public education in the matter of sanitation and public health is advancing in the concept of what constitutes a good public water supply. The old demand for quantity has passed on to a demand also for quality.

For many years St. Paul boasted of its pure water, and then, by ordinance, restricted the sale of water by sprinkling bans in summer and by limiting the size of service pipes—a city, with millions invested in a plant to sell water, doing everything in its power to dis-

courage its use. Today, it does everything in its power to promote use. The new ordinance specifies the minimum sizes of service pipes and meters. Small pipes not only restrict sales, but what is more important to the cause, bring complaints on the sales made. When the demand becomes more than can be delivered, a plant that can deliver should be built. This is in no sense to be taken as a commendation for the willful waste of water. Good service certainly does not imply the sale of water for non-legitimate purposes nor the waste or unwarranted use in those systems facing temporary or permanent water shortages beyond their immediate control; but where the supply is ample, the old order of restricting its use should pass on. A water work's business should be to sell water—all the water the consumer wants—in other words, to promote sales. Further, there should be a realization that responsibility begins on the day that the prospective consumer first makes inquiry. The department should be vitally interested, not only in the sale of water, but in satisfactory service. This implies a knowledge of the conditions under which sales will be made—probable demands, existing pressures in the street, the size of the consumer's lawn, the number of fixtures; in short, a control by the department of the proper size of both service pipe and meter. And in order that the cart shall not be before the horse, it is suggested that the water department should approve the water supply proposed for any new structure before a building permit be issued. Competitive bidding on a job by plumbers should not be permitted to influence service. The apparent economy to the consumer of a small connection will soon be forgotten. Poor water pressures will always result in complaints. To the same, or similar, ends, the water department should, through proper licensing, have some check over the workmanship of the plumber.

Administration of Sewer Rentals

With the large increase in the number of sewage disposal plants during the past few years, the question of sewer rentals has become very prominent. Since water departments have already set up methods of collections for water bills, the growing tendency has been, and with considerable logic, to combine the collection of water charges and sewer rental charges. Thus, the problem has in many cities, and in ever increasing instances, been turned over to the water departments. While in itself it may not be closely allied to efficient

operation, it may easily be a problem and headache which will affect the efficiency of the superintendent.

Sewer rental charges became effective in St. Paul on January 1, 1939. A word as to what a year's operation has taught may be of interest. The Minneapolis-St. Paul Sanitary Disposal Plant is jointly operated by the two cities, costs of operation being equitably apportioned as between the cities. St. Paul sewer rental rates are based on the size of the water meter as shown in Table 1.

Some 2,000 commercial accounts, over one inch, are billed monthly, and about 56,000 domestic accounts are billed quarterly. The smallest and most frequent bill is $2.40 a year and the largest is about $5,000.00 a year. Water meters are owned by the department, except in the case of private wells which are required to meter at their own expense. While at present there is no relationship

TABLE 1

Sewer Rental Charges in St. Paul

SIZE OF METER	ANNUAL CHARGE	SIZE OF METER	ANNUAL CHARGE
in.		*in.*	
$\frac{5}{8}$	$2.40	3	$75.00
$\frac{3}{4}$	3.00	4	180.00
1	5.00	6	360.00
$1\frac{1}{4}$	9.00	8	630.00
$1\frac{1}{2}$	15.00	10	900.00
2	30.00	12	1,350.00

between sewer rental charges and water consumption, an actual record of well meter readings is made to determine the consumption, now estimated at about fifteen million gallons per day.

The sewer rental revenue in St. Paul is designed to take care of its share of the operating costs only. The fixed charge portion of St. Paul's share of the Twin City district costs is raised through general taxation with an annual levy of approximately 1.5 mills.

In order that those outside of the city, using the sewers, may have no advantage over the citizens proper, the council has doubled the sewer rental charge, and has established a so-called service charge of $6.00 per year per connection in lieu of taxes.

Water bills were revised so that the two charges are carried on the one bill, and payment for water cannot be accepted without payment for the sewer rental. Accounts are kept entirely separate, and the

department has been reimbursed for all expenses incidental to the turnover in system, as well as for the current expenses of billing and collecting. The delinquency penalty is the same for sewer rental charges as for water.

In the beginning, an immense amount of work was involved, including the replacement of all accounting machines and equipment, the making of 60,000 new ledger cards, the transfer of all readings and accounts, the printing of innumerable new forms, and the employment of much temporary and some permanent help. Today the routine has pretty well leveled off, but, unquestionably, it does involve considerable additional work and worry. Good publicity aided a great deal, but since the department is the collecting agency it must of necessity accept all complaints.

Since all charges are based upon the size of the meter, it was not long before hundreds of requests began pouring into the office for reduction in meter sizes. Since the water charge is made up of two charges, for water consumed and for the demand or service charge, based upon the meter size, these requests, when granted, represented a loss in revenue to the water department.

Effect of the Depression

The administration of municipal water plants during the past few years has been particularly difficult. With increased costs of labor and materials on the one hand and economic conditions demanding strict economy, decreased budgets, increased demands, large delinquent lists, demands for P.W.A. and W.P.A., etc. on the other, the water engineer and manager have had to go through a cycle of years that have tried every resource at their command. Consumers have become increasingly critical. The best has been demanded and expected, but with ever decreased cost. Those out of work have been quick to resent the steady employment afforded municipal employees. Both management and employee have had to exercise extreme good will and tact in dealing with any type of complaint.

We are probably still too close to the problems to say accurately what history will record, but we may admit, or at least hope, that it will shortly appear, in review, to have been an interesting experience. These experiences, although often trying, have been healthy ones. We at least have been put on our toes. The value of good public relationship is being evidenced more each day, and the successful

water works man of tomorrow will learn much from private public utilities in the arts of public relations, public salesmanship and management.

It has been said that legally and theoretically the only function of a water supply is service. The complex nature of water treatment and its essentiality for modern industrial and domestic existence, however, have placed it alongside any big business in the field of industry and commerce. If service is first consideration, service efficiently given must be an obligation. With relief from outside influence, the water works manager should neither ask nor receive exceptions to the rules which govern the efficient management of private industry.

A Program of Equipment Replacement

By A. M. Brenneke

THIS paper is presented from the viewpoint of a small plant operator with the thought that some of the comments might be of value to other small plant operators.

The author believes that all operators should strive to improve the quality of their product and the service they render and at the same time reduce costs. This statement is so general and so commonplace we are often prone to say "of course," and then proceed to forget all about it.

Any program looking toward the modernization of a water works plant must be based upon complete operating cost records and upon complete operating performance records, as these two records will form the basis with which to compare the performance of existing equipment and the performance which may be expected from any particular type of equipment proposed. It is therefore necessary that these records be available over a period of years and in sufficient detail to cover the range of operation.

It is not necessary to go into great detail about operating records for a treatment plant. They should show the volume treated, the condition of water entering the plant and after each step in the treating process, and the quantity of chemicals used. Usually these will be column headings, with a line for each day and a month's operations on one sheet.

Whatever treatment may be given the water—softening, iron removal, or merely clarification and disinfection—there have been enough improvements made in the past twenty years in methods, materials and equipment to justify a careful study to determine what improvements in plant operation or results might be secured, and at what cost. The fact that a plant has been operating satisfactorily

A paper presented on April 22, 1940, at the Kansas City Convention by A. M. Brenneke, City Engineer, Denison, Texas.

for twenty years is no justification to leave it alone. Too often this course of least resistance is the policy adopted. The operator who does this is not giving his best efforts to the community because he is really putting forth no effort.

Manufacturers of water treatment equipment and chemicals and designing engineers are constantly improving treatment methods and applying this added knowledge in the construction of new and enlarged plants. It is certainly worth while to examine some of these methods, materials or equipment, to determine the possibility of their application to an existing plant.

Often the change from one coagulant to another, for instance, will reduce operating costs or improve the quality of the product, or both. Better flocculation could possibly be secured by installing a mechanical stirring device prior to settling. Such a change might reduce the coagulant required, perhaps enough to pay for the installation. The only way such questions may be answered is by experiment, even on a laboratory scale, comparing the indicated cost or result with the present actual cost or result.

In taste and odor control, the recent development of break-point chlorination gives promise of being the solution for many operators, but may very well fail for others. Such developments seem well worth a trial on the possibility that they may work, and even if they do not, nothing is lost by the experiment. Softening plants have changed materially in the past few years. They are now being condensed to the point where construction cost is not nearly so heavy, and where operating costs are as low as or lower than they were fifteen years ago. These examples mention only a few of the many recent developments in the field, but will serve to focus attention on the necessity for keeping up to date.

The demand by the public for softer more palatable water is increasing and will continue to increase until a uniformly high quality has been obtained in every community. To meet the challenge by delivering a water of better quality before such demands are made by the public will keep any operator busy. The author believes it is the operator's duty to lead in this effort rather than to be driven to action by the demands of the consumers.

An operating record of any pumping plant should show, in twenty-four-hour periods, the total volume of water pumped and the fuel or energy consumed in pumping this water, preferably on a sheet large enough to hold a month's operation record, with space for the monthly

total, the minimum and maximum days and the daily average. There should be columns for the quantity and unit cost of fuel or energy so that this can be converted daily into cost per thousand or per million gallons. Such a record will show at a glance any unusual conditions that may arise and will show, over a period of time, any gradual change, in the condition of the equipment, which will materially affect operating costs. These statements are, of course, general. The experience at Denison, Texas, about three years ago, however, may be given as a specific example.

Replacement of Pumps at Denison

At the time, pumping plant records indicated that the centrifugal pumps and motors were slowly losing their efficiency. This indication led to a careful check of the equipment and an investigation of equipment that could be secured to replace the pumps, which were, at that time, nineteen years old. Comparison between operating cost and expected cost from new equipment indicated that the new equipment could be paid for in power saving in about two years. The old equipment was, therefore, scrapped and replaced with modern pumps and motors. Performance and cost records since that time have clearly proved the expected saving and have justified the installation of the new equipment. To keep obsolete equipment is not only costly, but is poor management and a waste of public monies.

Along these lines a brief résumé of some of the equipment developments may call the reader's attention to what might be done in his plant by scrapping old equipment and replacing it with modern.

In regard to centrifugal pumps, Peterson, in a paper entitled "Twenty Years' Progress in Centrifugal Water Works Pumps" (Jour. A.W.W.A., **25**: 1372 (1933), showed, in general, that centrifugal pumps had shown an increase in efficiency of from 15 to 20 per cent within the fourteen years immediately preceding that time. This amounted to a power cost reduction of more than 20 per cent—no small sum of money in any plant. More recently, the author opened bids on four pumping units ranging from 700 g.p.m. against 70 ft. of head to 2,500 g.p.m. against 250 ft. of head. The bids received guaranteed pumps and motors of overall efficiencies ranging from 74 to 77.8 per cent.

It is interesting to see what economies could be effected, for instance, in a plant pumping 10 m.g.d. against 200 ft. of head with an old

steam-driven pumping unit. The old triple expansion condensing pumping engine with 150 lb. saturated steam pressure will deliver about 110,000,000 ft.lb. of duty per 1,000 lb. of steam, and will use about 495 lb. of oil per hour in the usual type of boiler. A modern turbine-driven pump, operating with around 400 lb. steam at 750°F. will show a duty of a little over 200,000,000 ft.lb. per 1,000 lb. of steam; and a modern boiler to supply this steam will use about 320 lb. of oil per hour as against 495 lb. in the older type plant. Oil-engine-driven modern pumps for this plant would use approximately 166 lb. per hr., or only about one-third as much fuel, to pump the same water against the same head as the old triple expansion steam pump.

This condition will not obtain in larger size plants, but it does show that equipment does become obsolete and that the operator must either replace it with modern equipment or pay for the modern equipment anyway in costs that are higher than necessary.

For smaller plants or for plants some distance from town one of the recent major developments is the use of liquified petroleum gases such as butane, instead of gasoline, fuel oil or natural gas, as a fuel for use in internal combustion engines. This fuel contains about 3,300 B.t.u. per cu.ft. or about 103,000 B.t.u. per gal. It is available through much of the middle west, and to some extent throughout the country, either in high pressure cylinders or by tank truck delivery into low pressure storage tanks. In the Southwest its price is about six or seven cents a gallon. It is used quite extensively in the oil fields as a fuel for internal combustion engines and practically all of the engine manufacturers furnish engines which use it as a fuel.

The operating cost is about one-half that of gasoline and the cost of the engine is only slightly greater than the cost of the gasoline engine. For standby service in an electrically operated plant, the author believes that this fuel will be as satisfactory as fuel oil and that the equipment will be considerably less costly.

Turbine pumps are accepted as the most efficient well pumps available today. One, specified for 1,000 g.p.m. against 250 ft. of head, with a 50-foot depth of setting and an efficiency of 83 per cent, was recently offered to the Denison water department.

In small plants the trend seems to be to the compact centrifugal pump driven by an electric motor or an internal combustion engine. The reasons are of course obvious, particularly when building and installation costs are considered.

It may be asked how such plant changes can be financed on a limited budget without issuing bonds. During the past ten years

the Denison water department has installed four pumping units with motors and scrapped two. The four units cost about $10,000. The largest cost at any time was $6,000 and this was paid for by a note, payable at the rate of $250 a month—the estimated power saving.

The pump company sold the note to a local bank. It was a cash sale as far as they were concerned. The department spent no more money monthly than it had been spending and after the note was paid spent less. All four units were purchased in this way and paid for by reduction in costs.

For a change that does not require too large an investment, such a plan seems to be the most logical, but any one of several plans will work.

In summary, it is believed that each superintendent should look at his plant as though it were in another town and with this perspective try to find every possible fault or defect. Then he should plan the best way to correct the condition and present the matter to the governing body with supporting statements of present results and costs together with expected results and costs, and one or more suggestions for financing whatever change is needed.

Even though the governing body may sometimes look upon such a matter with disfavor, the superintendent will have done all he could and the public will be with him for trying to keep the plant up to date and economical of operation.

Discussion by *George S. Rawlins.* * The best discussion of Mr. Brenneke's paper which the writer can give is to substantiate the author's conclusions with data from his own experience with an equipment replacement program at Charlotte, N. C.

A program of improvements for the Charlotte water works was started in March, 1937, and completed in February, 1939. The program included new pumping units at the Catawba River Pumping Station, new station piping, new controls, an additional force main, and other work.

The Catawba River Pumping Station is situated on a power company's reservoir, about nine miles from the filter plant, and is used to pump raw water about five miles to a balancing reservoir, from which the water flows by gravity to the filter plant. The original station equipment consisted of three motor-driven centrifugal pumping units having nominal capacities of 5 m.g.d. each. Two of these

* Civil Engineer, Charlotte, N. C.

units had been in service for about 25 yr. and the third for 14 yr. A booster station had also been set up a short distance along the force main to provide sufficient capacity to meet the demand. The situation became acute in 1936, when the system was barely able to meet the demand. The pumping main was a 24-inch cast-iron line laid in 1913, and cleaned in 1936.

The new synchronous-motor-driven pumping units have nominal capacities of 8, 10 and 12 m.g.d. One of the old units was retained as a standby and for use during the change-over period. New

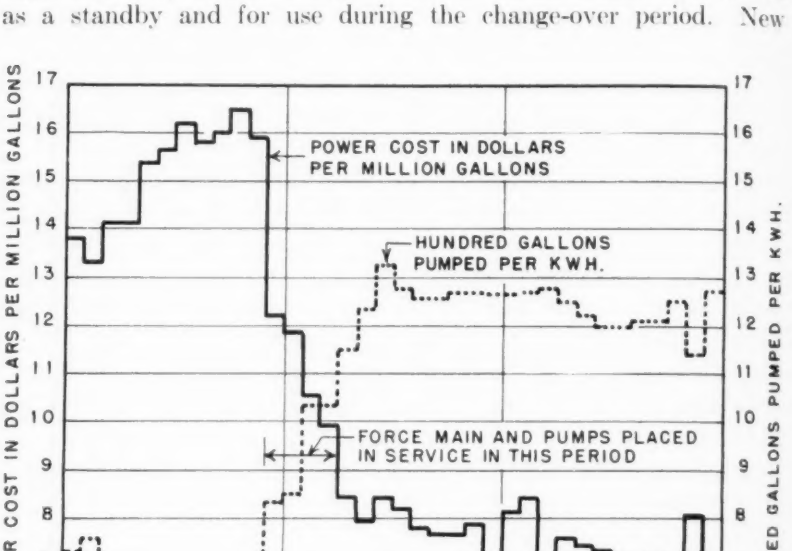

FIG. 1. Relation of Power Cost to Installation of New Equipment

switch-gear was installed in completely enclosed cubicles. The pump efficiencies according to field tests on the new units were 85.5, 89.1 and 91.7 per cent as against 56 and 66 per cent for the old units. The station piping was replaced with new and large piping. Cone type valves were used on the pump discharges and a surge limitator was installed on the end of the header to control the surge. A new Venturi meter was installed in the new force main, with the old Venturi meter moved to a new position in the old main. The new 30-inch cast-iron force main parallels the old 24-inch main and is approxi-

mately 28,000 ft. in length. Valved cross-connections were made about every mile.

The static head from normal level in the suction well to the overflow at the balancing reservoir is 168 ft. Suction lift varies with the level in the lake due to regulation by a hydro-electric station down stream. Total dynamic head with normal level in the suction well and both force mains in service is 190 ft. with a flow of 12.25 m.g.d.

The first section of the new force main was put in service during December, 1937. The entire main and the new pumping units were in use by the end of March, 1938. Testing of the pumps was carried out at a later date.

The total cost, including construction, engineering, legal and right-of-way costs, of the force main, pumping units and changes to the pumping station structure was $362,722.44.

The effect of these improvements upon the cost of operation of the pumping station was very marked. Figure 1 covers the period from 1937 through 1939 and shows the cost of power per million gallons pumped and the amount per kilowatt. The period from December, 1937, to March, 1938, has been eliminated from the following analysis because it was during this time that the new main and pumps were being put in service. The average volume of water pumped from January to November, 1937, when the old line and pumping units were in service was 7.43 m.g.d. The cost of power for pumping this water was $15.15 per mil. gal. For the period from April, 1938, to December, 1939, when the improvements were in use, the average volume pumped was 7.95 m.g.d. and the cost was $7.60 per mil. gal. or a reduction in cost of 49.8 per cent. The corresponding amounts of water pumped per kilowatt hour were 663 gal. and 1,235 gal. or an increase of 86.3 per cent. The annual saving in cost of power during this period was $21,951.12.

The bonds used to finance the improvements carry an average interest rate of 3.28 per cent, and the average annual cost is $42.15 per $1,000. If the saving in power costs is applied to payment of interest and retirement of principal, an amount of $520,788 in bonds can be supported by the savings alone. This is $158,066 more than the cost of the improvements.

These figures certainly indicate that the improvements were a good investment even aside from the fact that they were necessary for maintenance of a dependable service.

Pipe Laying Up To Date

By Philip Burgess

IN A previous paper (1), discussing the responsibility of water works operators for damage resulting from breakage of pipe lines in a water distribution system, the author stated that "in order to avoid possible payments of damage claims from leaks, a city must construct its water pipe lines in a proper manner, in accordance with best practice." It is thought that it may be of interest to the members of the Association to follow up this discussion and to indicate in a general way what seems to be the best modern practice with respect to the construction of pipe lines.

There are, of course, a great many special features which may have to do with the selection of the materials and labor entering into the construction of a transmission or distribution pipe line system, but it is the author's intension now to consider only the broader aspects of the question such as would ordinarily affect the construction of pipe lines up to 20 inches in diameter. In other words, only those problems of pipe line construction which the average water works superintendent is continuously encountering in the usual course of his duties shall be considered.

In the normal course of affairs and under the pressures usually encountered, it was customary for many years to purchase Class B pipe, as covered by A.W.W.A. specifications. Probably this practice would have continued except for the development of new processes in the manufacture of cast-iron pipe and the development of competitive material. Within the past 15 to 20 years, centrifugal processes of manufacturing cast-iron pipe have been perfected and these methods have greatly increased the strength of the pipe, resulting in the use of thinner wall sections than were formerly furnished under standard specifications for pit-cast pipe.

A paper presented on May 9, 1940, at the Ohio Section Meeting, Akron, Ohio, by Philip Burgess, Consulting Engineer, Columbus, Ohio.

Specifications for Pit-Cast Pipe

When the centrifugal processes were first put into effect, the thinner pipe, in some instances, did not have sufficient wall thickness, and, as a result, various failures occurred. Such failures appear to have been due largely, not to failure of the pipe to carry the internal water pressure, but rather to outside forces working in conjunction with this pressure. Recently, an A.W.W.A. committee, working jointly with representatives of the American Gas Association, the American Society for Testing Materials and the New England Water Works Association, as Committee A21 of the American Standards Association, produced new standard specifications (2, 3, 4) covering the manufacture of cast-iron pipe. These specifications take into consideration all of the elements which control the work which the pipe line has to do and the forces it has to resist, including such factors as internal pressure, water hammer, method of laying, depth of trench, truck loading over pipe, corrosion of material, and factor of safety. A discussion of the new law of design, published in the JOURNAL for October, 1939 (5), presents the manufacturer's point of view on the new standards.

Each of these specifications shows the methods of computing the thickness required for cast-iron pipe of any known strength characteristics and installed under any of the usual conditions ordinarily encountered in the water distribution system. Data contained in the publications are necessarily of a technical nature. If a superintendent of a water department has a special problem, which requires consideration of special service conditions, he should discuss it with a water works consulting engineer or with a representative of the pipe manufacturers to secure his recommendation before purchasing the required pipe line material. Some of the material discussed in the *Manual* undoubtedly presents new ideas to the average water works superintendent and should help him to arrive at a better understanding of the reasons why proper care must be exercised in constructing a distribution system. The *Manual* should be very helpful to him in securing a satisfactory job.

It will be observed from Table 1 that certain minimum thicknesses have been adopted for all sizes of pipe. Furthermore, as shown in the table, with flat bottom trenches and tamped backfill, for pipe carrying even up to 100-pounds working pressure, a minimum thickness is adequate, at least for a 5-foot cover.

As previously stated, until recently it has been common practice for the water works management to purchase Class B pipe as required for extensions. It is obvious from the table that, with first class laying conditions, the management may, if it so chooses, use a pipe substantially lighter and of less thickness than Class B. In other words, it is obvious that the use of Class B pipe, properly in-

TABLE 1

Specifications for Thickness of Pit-Cast Cast-Iron Pipe

SPECIFICATION	DIAMETER OF PIPE				
	6 in.	8 in.	10 in.	12 in.	18 in.
	in.	in.	in.	in.	in.
N.E.W.W.A. (1902)—Class E	0.46	0.53	—	—	—
N.E.W.W.A. (1902)—Class D	—	—	0.56	0.61	0.75
A.W.W.A. (1908)—Class B	0.48	0.51	0.57	0.62	0.75
A21.1—1939					
100 lb. Pressure—5 ft. Cover					
Laying Condition A*	0.43	0.46	0.50	0.54	0.68
" " B	0.43	0.46	0.50	0.54	0.63
" " C	0.50	0.54	0.63	0.63	0.79
" " D	0.43	0.46	0.50	0.58	0.73
100 lb. Pressure—3½ ft. Cover					
Laying Condition A	0.43	0.46	0.50	0.54	0.68
" " B	0.43	0.46	0.50	0.54	0.63
" " C	0.46	0.54	0.58	0.63	0.73
" " D	0.43	0.46	0.50	0.54	0.68
150 lb. Pressure—3½ ft. Cover					
Laying Condition A	0.43	0.46	0.50	0.58	0.73
" " B	0.43	0.46	0.50	0.54	0.73
" " C	0.50	0.58	0.58	0.63	0.79
" " D	0.43	0.46	0.50	0.58	0.73
A.W.W.A. (1908)—Class A	0.44	0.46	0.50	0.54	0.64

* Laying conditions: A—Flat bottom trench, untamped backfill
B—Flat bottom trench, tamped backfill
C—Pipe laid on blocks, untamped backfill
D—Pipe laid on blocks, tamped backfill

stalled, has been conservative practice and has provided adequate factors of safety for the usual uncalculated external loads, a fact which undoubtedly has contributed to the long service value of cast-iron pipe distribution systems.

These data also disclose that, with poor construction and particularly in the case of pipe laid on blocks with untamped backfill, a

substantially thicker and heavier pipe is required than would otherwise be satisfactory. Class B pipe, however, is generally satisfactory even for poorly installed pipe lines. It is obvious, therefore, that the work of the committee has resulted in the conclusion that it is proper and good practice to use somewhat lighter pipe than has heretofore been used, provided that the pipe is well bedded in flat bottomed trenches and that the backfill is properly tamped. In fact, generally speaking, the new specifications—especially for the smaller sizes of pipe—permit the use of Class A pipe where it has formerly been considered good practice to use pipe of the thicknesses corresponding to the old Class B. This is a step in the direction of securing lower construction costs.

A good many water works superintendents will, no doubt, continue to purchase the heavier pipes, with the understanding that the added cost is for extra metal which, in their minds at least, gives a greater assurance of safety under any conditions of installation. This is especially true in the case of long single transmission mains and in the case of pipe lines laid in congested metropolitan districts, where they may be subject to more stresses from outside sources than in suburban areas, and where the pipe line is not easily accessible for repair because it is under permanent heavy pavement.

Specifications for Pipe Laying

In the above discussion, it has been shown that the proper determination of the metal thickness of the pipe depends, in part, upon the conditions of pipe laying. Next, it is of interest to consider the proper methods which the water works superintendent should pursue in installing the pipe lines. The JOURNAL of February, 1938, contains specifications for laying cast-iron pipe (6). These specifications contain eighteen sections which cover all the features usually encountered in work of this character. They are founded on good engineering and water works practice and represent knowledge acquired through long experience.

Under Section 6.3, "Depth of Pipe Cover," appear the following notes:

"The minimum depth of cover over water pipe should be determined by: (1) the maximum depth of frost penetration in the locality where the pipe is to be laid, and (2) the direct effect of loaded trucks.

"The depth of cover and the nature of the trench bottom are two

primary factors in the determination of metal thicknesses. Metal thicknesses, as developed from calculations by the American Standards Association Committee A21, take into account four distinct trench conditions and two types of backfill and varying depth of cover. *A cover of about four feet, with a flat-bottom trench and tamped backfill,** usually results in the most favorable combination of earth and truck hazard.

"Where failures in cast-iron pipe lines occur, they usually result from settlement, careless laying, flat slope trenching, bedding on rock, improper backfilling procedure, impact from loaded trucks, or rupture from freezing because of shallow cover. These and other external and internal hazards should be carefully considered before the line is laid."

This information shows clearly how methods and conditions of pipe laying must be considered in determining the required strength and thickness of the pipe line material.

Another factor which affects the thickness and strength of pipe line material is the use of blocks, referred to under Section 9. It is, of course, true that these blocks are furnished primarily for the purpose of facilitating the making of a satisfactory joint. It should be appreciated, however, that pipe laid in this manner may be subject to beam action due to the superimposed earth load, and, consequently, is not as strong as it would be if the pipe were laid directly on the bottom of a flat trench.

Still another important feature in determining the strength of a pipe is the method used for filling the trenches. Concerning this, Section 16.1, "Backfill Procedure at Pipe Zone," reads, in part, as follows:

"Selected backfill material, free from rock or boulders or other unsuitable substances, shall be deposited in the trench simultaneously on both sides of the pipe for the full width of the trench, and to an elevation of at least six inches above the top of the barrels of pipes eight inches or less in diameter, and not less than six inches above the horizontal center line of pipes with diameters twelve inches or larger, leaving the joints exposed for examination during the pressure test specified in Section 15. The backfill material shall be moistened if necessary, tamped in thin (about 4-inch) layers, and thoroughly compacted under each side of the pipe, to provide solid backing against the external surface of the pipe."

* Author's italics.

It is obvious that backfilling in accordance with the above specification is more expensive than backfilling by the use of machines or other devices. It is further apparent that the question of cost of pipe laying under approved methods, as compared with methods where tamping is not required, is a factor substantially affecting the ultimate cost of a pipe line just as much as the thickness of the pipe shell. In other words, the old practice of selecting Class B pipe and placing backfill, without tamping, by flushing material deposited in the trenches, may have incurred a somewhat higher price for material, but did not entail as much expense to backfill the trenches as is necessary when a lighter pipe is used. The added expense of installing a thinner pipe may be equal to the saving in cost of pipe line material. This fact should be considered in selecting the thickness and weight of pipe required.

Specifications for Centrifugally-Cast Pipe

The specifications for pit-cast pipe are based upon the physical factors of a minimum of 11,000 lb. tensile strength and a minimum modulus of rupture of 31,000. Pipe manufactured by the centrifugal process has a much stronger metal. It is understood that Committee A21 is now working upon the formulation of specifications for pipe other than pit-cast, wherein the minimum strength values applicable to the entire group will be at least 18,000 lb. per sq.in. tensile strength and at least 40,000 lb. per sq.in. modulus of rupture. The method of design for cast-iron pipe, already determined and described in the *Manual*, has been worked out so that no changes will be required for cast-iron pipe possessing other physical strength values.

Under the Federal specifications (WW-P-421) for centrifugally-cast cast-iron water pipe, Class 150 is used generally for service formerly using pit-cast pipe Class B, of the old A.W.W.A. specifications. As would be expected, the walls of the centrifugally-cast pipe are substantially thinner than those of the pit-cast for the same service conditions. With the use of the lighter pipe, it is important to assure proper installation and testing.

Strength Factors in Pipe Lines

It is not the intention, here, to discuss the relative merits of the several kinds of pipe line materials available, though all are recognized to have some particular advantages. We are, however, im-

mediately concerned with the strength factors of pipe lines, so it would seem wise to refer to Howson's interesting and instructive paper, entitled "Adaptability of Pipe Line Materials" (7).

The statement that—"In water works service it is, of course, recognized that safety is the first consideration."—is one which, in the author's belief, is indisputable to anyone involved in the operation of a water works system. In recognition of this fact, Howson develops his paper on a discussion of the relative "Factors of Safety" and "Total Strength per Dollar First Cost" for pipes made of steel, cast iron, and asbestos-cement (transite). The data were based upon light weight and standard weight steel pipe, cast-iron pipe, Federal Standard Class 150 centrifugally-cast pipe, and Class 150 asbestos-cement pipe. His conclusion was that the metal pipe offered a factor of safety three to four times as great as the asbestos-cement pipe and that a generally similar relation held with respect to the total strength per dollar first cost.

If we accept Howson's conclusions, and there seems to be no reason why we should not do so, does it not follow either that the metal pipe heretofore furnished has been unnecessarily strong or that the asbestos-cement pipe now offered is too weak? Should not the water works superintendent, who uses the asbestos-cement pipe, realize that it may be only one-quarter to one-third as strong as the metal pipe (nominally of the same class) now being offered? It is very important that he be advised to use particular care in laying the asbestos-cement pipe to make sure it is well bedded and that the backfill is tamped around and above it to avoid breakage and possible resultant damage. This is particularly the case in the smaller sizes of pipe.

Jointing Materials

An important feature which affects the stability and service of a pipe line is the method used to secure proper jointing. To date, bell and spigot ends, with joint material of lead or of sulfur compounds, have generally been considered as standard construction. Joints with elastic packing, however, appear to be gaining ground where lead joints have been found to have undesirable features.

Lead is very durable but has no elasticity, and has a tendency to work loose under the vibration caused by modern traffic. In some instances, engineers of the Ohio State Department of Highways require that, in advance of new permanent paving, cast-iron pipe lines which have been in service for some time, even without any

apparent leakage, be uncovered and the lead joints secured by steel bands. In Columbus, the local gas company has installed such bands over a large percentage of the lead joints in the cast-iron pipe of the local system.

For some time the gas industry has realized the weakness of lead joints and has been instrumental in the development of flexible joints with elastic packing. Within recent years, the water works industry also has come to appreciate the advantage of such joints for water distribution service. They can be made by unskilled labor with little inspection, are bottle tight and permit considerable flexibility. Cast-iron pipes with flexible rubber joints or gaskets can be installed at less cost than similar pipe with lead joints. As indicative of its increased use, it is to be noted that pipe with this type of joint is now practically standard practice for gas service in the cities of Chicago and Detroit.

The pipe manufacturers offer several types of joints, with flexible packing for joint material, but the scope of this paper does not permit a description of these joints, all of which have certain desirable features. Among the most recent types is a joint which utilizes round rubber rings, deformed and positioned in the joint as the spigot is pushed into the bell end of the pipe. A somewhat similar joint is used on some types of asbestos-cement pipe wherein round rubber rings are used in combination with a sleeve type coupling. The joint generally is tight but offers little resistance to pulling out at dead ends or where short branches or valves are attached to the main pipe line. In such instances, it is necessary to brace the dead ends to avoid separation of the joints.

In the case of a bell connection with this type of joint, it is possible to fill in the open portion of the bell outside of the gasket or rubber joint material with a plastic compound which eliminates dirt and protects the rubber. The sleeve type of joint is flexible when installed but if dirt enters the joint between the sleeve and the pipe, the flexibility is lost and the pipe becomes more liable to breakage.

The better joints have a wedge shaped gasket held in place by a cast-iron follower which, in turn, is drawn up and held in place by bolts fastened to lugs or rings on the ends of the pipes. In these gland-packed joints, the rubber is restrained from cold flow and undue distension. The rubber is locked up under compression—a prime requisite for long life service. Such joints are flexible, bottle tight and durable.

The author appreciates the fact that he has touched only the high spots of the subject of modern pipe installation, but he wishes again to emphasize the fact that securing a satisfactory pipe line job depends upon selection of the right pipe, proper testing and proper methods and conditions of installation, all as required for the particular situation at hand. Committee A21 has performed a real service in bringing out the specifications for pit-cast pipe. Most of the cast-iron pipe now purchased, however, is made by the centrifugal process, and it is hoped that the committee will bring out its specifications for centrifugal pipe at an early date. In the meantime, we shall go along as we have in the past giving first consideration to safety so that we may not be found negligent in the performance of our duty of providing water distribution systems which shall be not only economical but also sufficiently strong to do the work required.

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† These documents became standard specifications, approved by the Board of Directors of the A.W.W.A. on April 28, 1938. They are now available in reprint form.

Service Life of Coal-Tar Enamel Protective Coatings

By Harry Hayes

HOW long will it last is a question frequently asked by water works engineers when investigating the problems of pipe line corrosion and methods of prevention by the use of coal-tar enamel protective coatings. This is a natural question for an engineer to ask, for he is interested in the length of life that can be assigned to a pipe line, how many years can be added to the length of that life, and how much the rate of flow can be increased and maintained through the line by the use of this protective coating.

Under the direction of H. A. Van Norman and W. W. Hurlbut, the Los Angeles Bureau of Water Works and Supply has laid and is laying many miles of steel water pipe coated with coal-tar enamel protective coating. The duty of finding an answer to the question of service life was assigned to the bureau's protective coating laboratory. In searching for the answer, many tests and experiments have been conducted and many new and old applications of protective coatings have been inspected.

The answer found is that coal-tar enamel, correctly used and applied as a protective coating, offers permanent protection against corrosion. The purpose of this paper is to give an account of some of the findings of the investigation.

One of the first lines of investigation followed was a search for records of the earliest applications of enamel that were still in service and that could be examined to determine present conditions. Wherever such records were found, arrangements were made to obtain a report of conditions at the latest inspection, or to allow an examination by the laboratory's inspectors. When a new inspection was made, pictures of the condition of the coating were taken for records.

A paper presented on April 23, 1940, at the Kansas City Convention by Harry Hayes, Jr. Civil Engineer, Field Engineering Investigations, Department of Water & Power, Los Angeles.

Some of the inspections made were of coal-tar enamel applied many years ago. The enamel used at the time varied considerably in many respects from that used today, but it is from these older applications that records of long years of service were obtained. The coal-tar enamel used at the time was a highly water-proof material, and when used under favorable conditions had an almost indefinite life, but it had some undesirable characteristics which limited its use.

Present Specifications for Coal-Tar Enamels

The coal-tar enamel used in water works systems today, as specified in A.W.W.A. standard specifications (1, 2), is made of the same basic coal-tar pitch, but has been so processed that practically all of the undesirable characteristics of the earlier enamel have been eliminated without deterioration of its water resistant qualities.* A description of the new enamel and methods of its application was published in the September, 1936, issue of the JOURNAL (3).

The bureau's decision to use coal-tar enamel was based on the record of service of this material in a water tank owned by the Southern California Edison Company at Long Beach. This tank was enameled in 1912, and was first emptied for examination and repairs in 1929. Above the lower water level some patching was required, where heat from the sun had made the enamel sag and "alligator," but below this level, where the enamel was under continuous submersion, it was in perfect condition, except that some patching was required on spots which were obviously pin holes and holidays left in the coating when it was applied.

With the present methods of electrical inspection, such flaws in application can be eliminated.

This tank was emptied again for inspection in 1939. The enamel was found to be in the same good condition as when previously examined.

Figure 1 shows the condition of enamel that has been in service on a tank for about eight years. This was one of the first of the bureau's tanks to be enameled. It was enameled with the same kind of material that was used on the Southern California Edison Company's tank. It will be noted that for about a foot or so down from the top, where

* In this paper the early application type of material will be referred to as the *original type* of enamel, and the newer enamels as the *improved type*.

the tank was shaded by the overhang of the roof, the enamel is in good condition, the brush marks still showing. Below this, down to the low water level, the enamel has sagged somewhat. This is not a failure, however, for in sagging, a film of enamel, thick enough to prevent rusting, was left on the steel. Below the low water level there were a few scattered rust spots that were due to holidays, but otherwise the enamel was as good as when it was applied. The condition of the enamel in this tank is typical of what has been found in

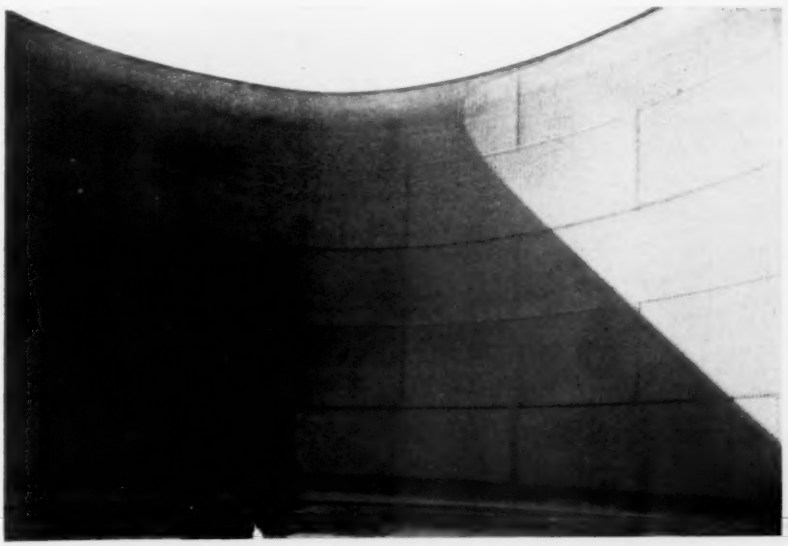

FIG. 1. Original Type Enamel on Interior of Water Tank After 8 Years' Service; showing some sagging above water line, but perfect condition below

all cases where the original type enamel was used before the new improved type was available.

Figure 2 shows an experimental patch of enamel in a penstock of the Pacific Gas and Electric Company of San Francisco. This enamel was applied in 1913, and was examined in 1939. Although the enamel was only 0.04 in. thick, there was not a rust spot or blister to be found; and, when the scum was washed off, the surface could be polished to look like new enamel.

The longest record of service of coal-tar enamel available to the writer was its reported use applied to the steel plates of a drydock

when built in 1892, at North Shields, England. The drydock was in continuous service until it was dismantled in 1938. Apart from an occasional patching to repair bruised spots, it was reported that the original coating was still intact. From the reports of the present condition of the enamel, it is evident that it would have lasted many more years if kept in service.

The foregoing illustrations are given for the purpose of showing that enamels made from a coal-tar pitch base are practically immune from deterioration from water absorption. All illustrations were of

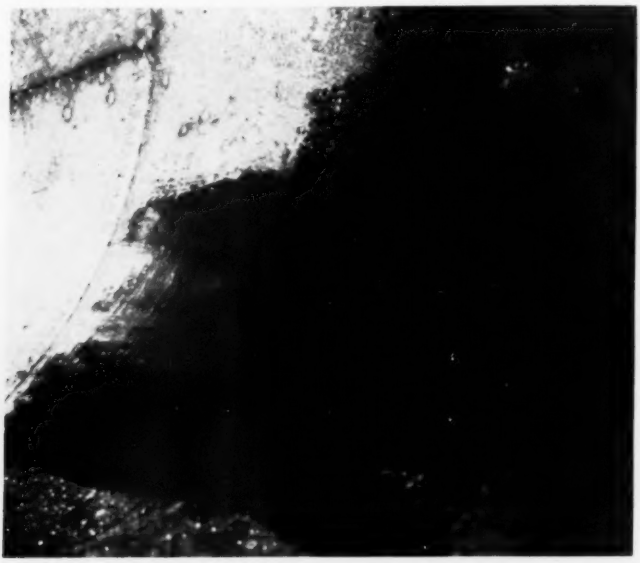

FIG. 2. Original Type Enamel on Interior of Penstock After 26 Years' Service; showing good condition of enamel and rough appearance, above cleaned spot, due to scum and algae

the original type, the only kind available at the time the applications were made. Their use was limited to applications under which they would not be subjected to too high or too low temperature conditions or to impact or abrasion. Illustrations of underground installations of steel water pipe coated with coal-tar enamel with service records of twenty to thirty years may be cited. A copy of a report of the inspection made in February, 1939, of the lining which had been applied on the 84-inch steel pipe for the City of Baltimore, Maryland, in 1915, was examined. The report states that the enamel was in

good condition except for some small tubercles. The number of tubercles was about equal to the number of pin holes ordinarily left in hand daubed work before inspection with an electrical detector.

In 1933, the improved type of coal-tar enamel was offered the bureau for coating the inside of its Bouquet Canyon Pipe Line (4). This line is a steel pipe 96 in. in diameter, supported on piers above ground and exposed to desert sunlight conditions. An enamel such as the original type would have been difficult to maintain under the existing conditions of the installation and use. The improved type of enamel, however, was found by tests to be much superior to the original type of enamel in its temperature susceptibility range and its ductility, and thus more suitable for the line. In fact, this enamel was more like asphalt in its physical characteristics than any of the other coal-tar enamels previously used.

The similarity of the improved coal-tar enamel to asphalt presented the question of its moisture permeability. Because of the change in the coal-tar pitch base, which made the enamel more plastic and rubbery, was the material more susceptible to moisture penetration?

Experiments on Moisture Penetration

The research laboratory of the former Los Angeles Gas and Electric Corporation, under the direction of Guy Corfield, had for some years been experimenting with tests to determine the resistance to moisture penetration of various types of protective coating material and to determine whether this characteristic could be used as an index to predict the probable length of life during which the material maintained its protective value as a coating for steel pipe for underground or submersion conditions. A test had been devised in which the moisture penetration was determined in terms of grams of water absorbed per square foot of coating area immersed (5). This test proved sufficiently accurate so that when results were plotted to coordinate with grams of water absorbed per square foot of area immersed, as the ordinate, and number of days immersed, as the abscissa, a typical water absorption curve, which was representative of its water absorption characteristics, could be drawn for each type of material tested.

A part of the investigations of water absorption characteristics was the correlation of test data against field experience with the various types of coatings. It was found that where soil conditions

and other factors could be compared on an equal basis, the life of a protective coating was dependent on, and varied with, its resistance to moisture penetration. Figure 3 shows typical water absorption curves of three materials currently used as protective coatings for steel. Curve A shows the typical water absorption characteristics of an asphaltic enamel, made from an air-blown asphalt mixed with an inert filler. Curve B is for the asphalt without the filler. It will be noted that with asphalts, the addition of fillers, which add mechanical strength and toughness to the material, increases susceptibility

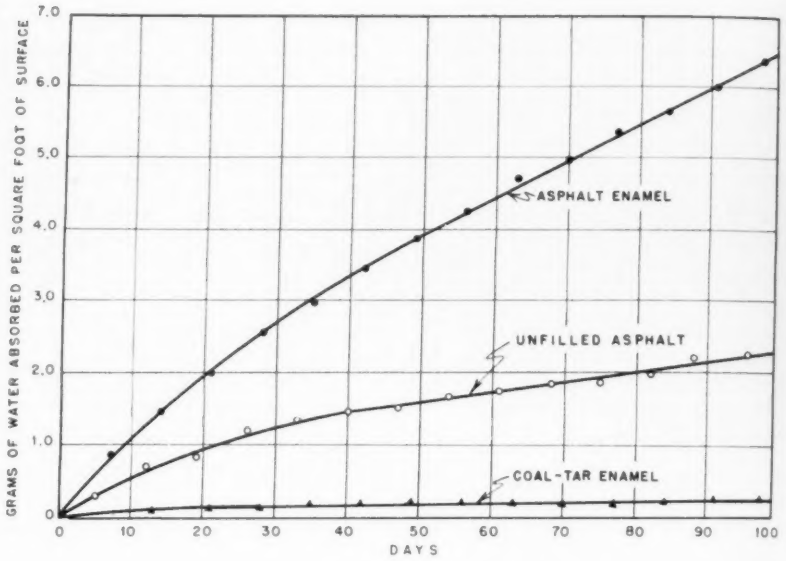

FIG. 3. Typical Water Absorption Curves

to moisture penetration, thus decreasing protective qualities. Curve C is a typical water absorption curve for coal-tar pitch base enamels. The curves for coal-tar enamel and unfilled coal-tar pitches do not deviate materially from each other, showing that the presence of a suitable filler in the enamel does not increase its water absorption characteristics nor decrease its protective qualities.

When the improved coal-tar pitch enamel was introduced to the bureau, a sample was given to Mr. Corfield for a water absorption test. When he reported that the trend of its water absorption curve followed along the typical coal-tar enamel curve, it was assured that

the protective qualities of the new enamel, as regards moisture penetration, were equal to those enamels for which long service records were available. All recent improvements in the improved type of enamels have been subjected to this test to assure that the water resistant characteristics have not been changed.

To illustrate the serviceable life of the two materials represented in Fig. 3, it will be well to present some examples.

Figure 4 shows the conditions of asphalt coating on the interior of a 52-inch pipe after six years in service. Blistering is apparent in about three years in a $\frac{1}{16}$ in. thickness of coating, and as the blisters

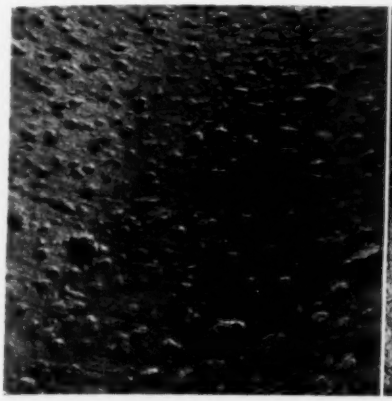

FIG. 4

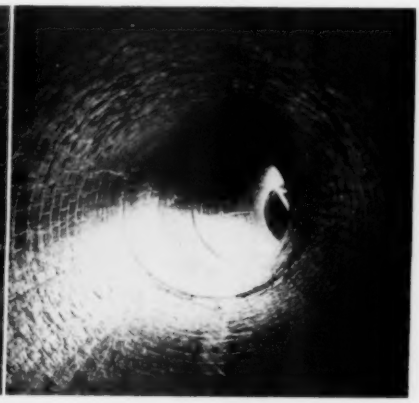

FIG. 5

FIG. 4. Asphalt Coating on Inside of Water Pipe After 6 Years' Service; showing blisters and tubercles on surface

FIG. 5. Improved Type Enamel on Interior of Bouquet Canyon Pipe Line After 6 Years' Service; showing unblemished condition of enamel except for deposits of slime and algae

grow and break, tuberculation starts. Figure 5 shows the condition of the coating on the interior of the Bouquet Canyon Pipe Line after six years service—the oldest service record of the improved coal-tar pitch type of enamels available to the department. The apparent roughness seen on the surface, in spots, is slime from an algae growth. The enamel itself is unblemished. Figure 6 shows an asphalt-dipped pipe after six years in a sandy soil. The streak down the side is water which ran out of a blister in the asphalt when it was broken. Since the pipe was laid in a mild soil there was no corrosion of the steel, and there probably would not have been if the pipe had been bare. Figure 7 shows the condition of coal-tar enamel on a

pipe after about the same length of service underground. Previously there had been asphalt-coated pipe in the same location but it failed so badly from corrosion that it had to be removed in nine years. The enamel on this new pipe is the original type, and because of the excessive corrosive and soil stress conditions in this area, the pipe was backfilled with about a foot of sand. The bureau considers this the ultimate requirement for protection of steel pipe for such soil conditions, and expects this protection to last for at least as long as the longest service record of coal-tar enamel available to the department.

FIG. 6

FIG. 7

FIG. 6. Asphalt-Dipped Pipe After 6 Years Underground in Damp Sandy Soil; showing streak down side where water ran out of broken blister

FIG. 7. Coal-Tar Enamel Coated Pipe After 6 Years Underground in Sand Backfill; showing perfect condition of enamel

Experiments on Abrasion Resistance

Another aspect of the improved type of coal-tar pitch enamel investigated by the bureau is its resistance to abrasion. When replacement of the steel in some of the aqueduct siphons was first proposed, consideration was given to the abrasive action of the sand and debris sometimes carried by the water. To determine the abrasion resistance of various types of protective coating materials, an abrasion test was set up which would give comparative results of the materials tested. Figure 8 shows the equipment used for making the test. The material to be tested was spun inside of the 18-inch outside diameter pipe rings, six inches long, and the rings were in-

inserted in the 18-inch inside diameter cylinder and separated with steel spacers and rubber gaskets. Sand, gravel and water were then placed in the bottom of the rings, and the cylinder rotated at a peripheral speed of about six feet per second. The rings were carefully weighed and profiled before the test and again after each 500 hr. Among the materials included were coal-tar enamels, asphalts, coal-tar mastics, asphalt mastics, spun cement mortar, hand-compacted concrete linings and sprayed metal linings, and bare steel.

Some very interesting and illuminating results were obtained. Of the materials listed, the original coal-tar enamel showed the great-

FIG. 8. Equipment for Abrasion Tests

est loss of weight from abrasion and the improved type coal-tar pitch enamels, the least. Asphalts were somewhat higher in weight loss than the improved enamels, but the asphalt mastic lost nearly as much as the old type enamel. Coal-tar mastics lost about the same weight as the enamels from which they were made. Improved coal-tar pitch enamels of varying degrees of hardness were tested, and it was found that the loss of weight of the enamel decreased as the penetration of the sample increased. Comparing the losses in weight of various materials with an improved type enamel having a penetration of 10 at 77°F., those of bare steel and spun cement

FIG. 9. Results of Abrasion Test on Sprayed Metal Lining

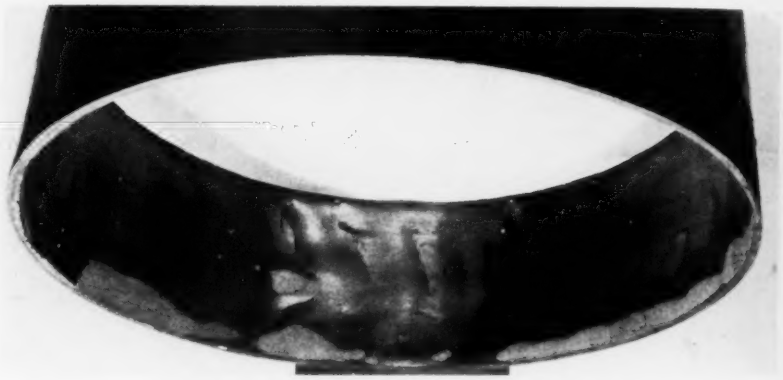

FIG. 10. Results of Abrasion Test on Original Type Enamel

FIG. 11. Results of Abrasion Test on Improved Type Enamel

mortar were three times as great; hand tamped concrete, five times; asphalt mastic, seven times; and original type enamel, fifteen times.

The sprayed metal lining was worn through and torn away from the steel. Figure 9 shows the results of the test on this lining; Fig. 10, on the original type; and Fig. 11, on improved type enamel.

A practical example of how the improved type of enamel withstands abrasion can be shown from the experience of the Los Angeles County Flood Control District with the outlet works of San Gabriel Dam No. 1 under flood flow conditions. The outlet lines which

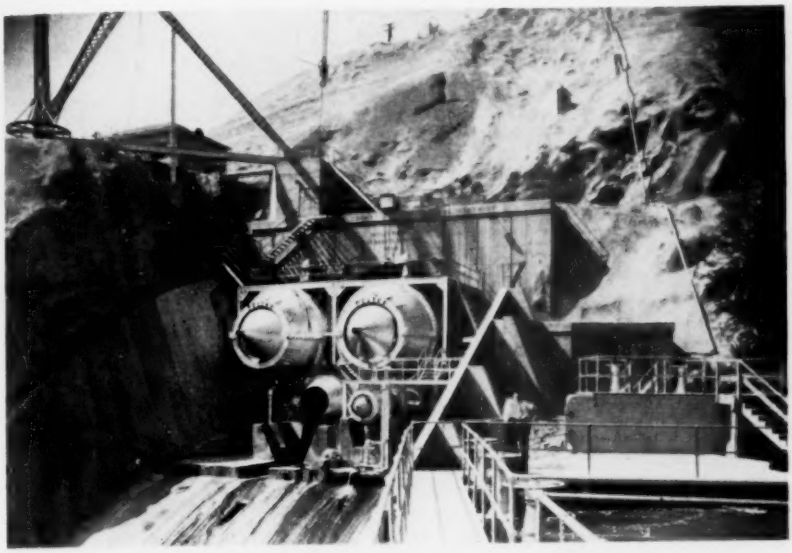

FIG. 12. Tunnel Portal and Outlet Nozzles, San Gabriel Dam No. 1

pass through the dam are composed of two 123-inch, one 96-inch and one 51-inch diameter steel pipes coated on the inside with centrifugally-spun coal-tar enamel lining. Figure 12 shows the tunnel portal and outlet nozzles.

Field Experience With Enamels

Prior to the construction of these lines, the flood control engineers conferred with the bureau's protective coating research men concerning the type of lining to be used. It was their fear that, whatever type of material was used for coating the steel, after each seasonal discharge of flood water it would be necessary to enter the lines and

replace the coating. Coal-tar enamel applied by a centrifugal method was used on the bureau's recommendation.

On March 2, 1938, Southern California experienced the worst storm in its records. The San Gabriel Dam, being partly filled with water from previous storms, was soon filled and overflowed its spillway. At the time, the only outlet lines that had been installed were the 51- and 96-inch pipes. The 51-inch line was completed and all field joints patched. It had been discharging water under normal flow conditions since the previous November. The 96-inch line had been

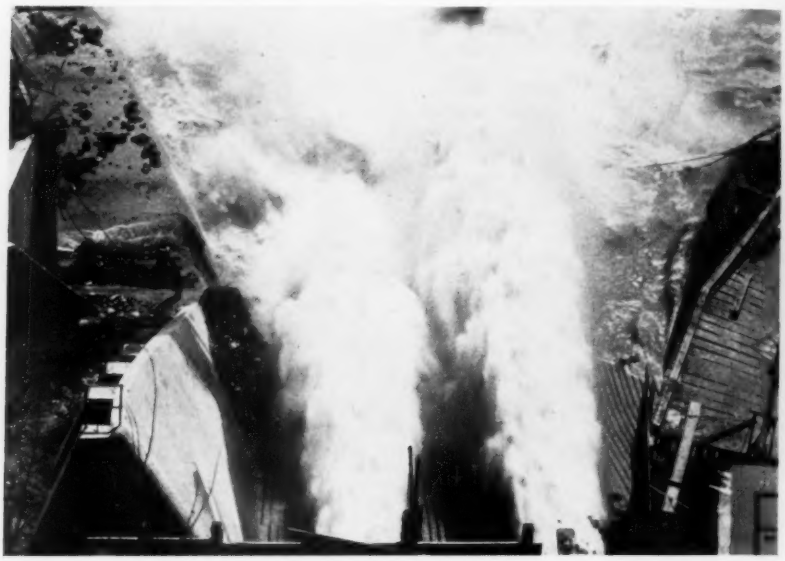

FIG. 13. Discharge of Water from Outlet Nozzles under Flood Flow Conditions, San Gabriel Dam No. 1

installed but no field joint patching had been done. To relieve the spillway, both lines were opened wide and allowed to discharge at their maximum capacity. Figures 13 shows these lines discharging the flood waters. The 96-inch line continued to discharge under these conditions for four days, and the 51-inch for two months, and thereafter both lines were used to flush out silt and debris that had accumulated about the intake. At the time of the flood, the intake tower had not been built, and all the debris, that accompanies the flood runoff from the mountains, passed through the pipes. Figure 14 shows some of the debris left in the bottom of the pipe.

The velocity of flow through the pipe during the height of the flood was estimated to be about 40 ft. per sec. for the 51-inch pipe and about 60 ft. per sec. for the 96-inch. Such velocities in enamel-lined pipe were theretofore unheard of. Upon entering the pipe, it was expected that most of the enamel would be found worn or peeled off by the terrific force and speed of such a mass of water, mud and debris; but no such thing had occurred. The only damage found was scarring, some broken patches in the invert, caused by the passage of rocks, and some scouring in the hand-daubed areas of the field joints which were rougher than the spun lining. The spun

FIG. 14

FIG. 15

FIG. 14. Mud and Debris Carried by Outlet Works during Discharge of Flood Water, San Gabriel Dam No. 1

FIG. 15. Coal-Tar Enamel Lining on Interior of 51-Inch Outlet Pipe, San Gabriel Dam No. 1, after discharge of flood water

lining was otherwise undamaged. Figure 15 shows the condition of the interior lining of the 51-inch pipe. Figure 16 shows an unfinished field joint with the square shoulder of the enamel lining practically unworn and undamaged.

In the May, 1939, issue of the Western Construction News (6), G. W. Outland, describes the outlet works of San Gabriel Dam No. 1. In his article flow measurements under maximum discharge made in the various pipes after completion of the project are given. The velocities of flow for the three sizes of pipe are as follows: for 51-inch pipe, 46 ft. per sec.; 96-inch pipe, 67 ft. per sec.; 120-inch pipe, 70

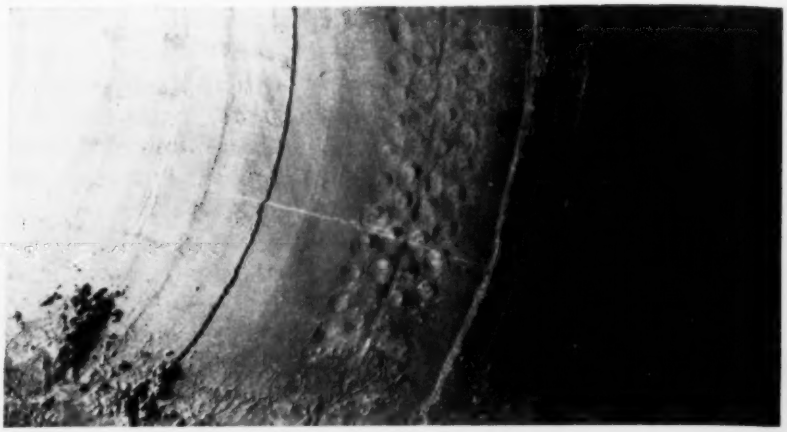

FIG. 16. Coal-Tar Enamel Lining on Interior of Outlet Pipe, San Gabriel Dam No. 1; showing undamaged condition of square edge of enamel at unfinished joint after discharge of flood water

FIG. 17. Bouquet Canyon Pipe Line

ft. per sec. The value of N in Manning's formula was shown to be less than .009 in all three cases.

To illustrate the amount of punishment the improved type of coal-

tar enamel protective coating can absorb, and to show the superiority of this material over the original type of enamel, two failures in a part of the bureau's system are indicative.

On March 10, 1933, the Los Angeles area experienced an earthquake sufficiently severe to shear off completely the two top courses of its Western Avenue tank. This tank was 150 ft. in diameter by 60 ft. high and was coated on the inside with the original type of coal-tar enamel. After the failure, the steel was examined to ascertain the condition of the coating, and in all areas where the steel

FIG. 18. Collapsed Section of Bouquet Canyon Pipe Line; caused by failure of automatic air relief valve

had been bent from its original curvature by as little as fifteen degrees, the coating had popped off like Tamarack bark before a bandsaw, leaving bare steel. The temperature of the water in the tank was approximately 60°F. at the time.

The evidence submitted to illustrate the amount of punishment the improved coal-tar enamel protective coating can absorb is an account of the collapse of a section of the 96-inch Bouquet Canyon pipe line. This line was completed in the spring of 1934, but was not tied into the aqueduct, except for two small diameter temporary lines used for filling the reservoirs, until the fall of 1934 (Fig. 17).

FIG. 19. Collapsed Section of Bouquet Canyon Pipe Line; after restoration by water pressure

FIG. 20. Lining on Inside of Collapsed Section of Bouquet Canyon Pipe Line; after restoration of pipe

To make the connection into existing penstocks, it was necessary to empty the line partially. The automatic air relief valves placed at the summits of the line had not been used since being installed, and, although men were placed at these valves to assist them in opening while water was being discharged from the blowoff valves, two could not be made to operate because of badly corroded conditions. This failure caused one section of the line, about 235 ft. long, to collapse completely and another short section to collapse partially. Figure 18 shows the completely collapsed section.

To reshape the pipe, water was forced back into the line under pressure, gradually rounding out the pipe to its original shape except for a few kinks that were later cut out and replaced with steel plate. Figure 19 shows the pipe after being restored. It was expected that the entire lining would be lying in the bottom of the pipe, but practically none of the coating had fallen off. Along the very top of the pipe there were a few spots where the enamel could easily be scaled off, but the rest of the coating was as tightly bonded as though there had been no collapse. Figure 20 shows the condition of the enamel after restoration of the pipe. A strip along the top, about two feet wide, and a strip along each side, about half-way up, for the same width, was badly cracked, requiring removal of the enamel before patching. The chipping of this enamel for removal was so difficult that it was decided to heat the steel on the outside with acetylene torches to peel the entire coating off and replace it with new enamel. The marks of the torches can be seen burnt into the paint (Fig. 19).

The temperature of the water at the time of the collapse was about 60°F. The enamel used on the Bouquet pipe line was the first development of the improved type coal-tar pitch enamel. The present development of this improved type will surpass the enamel used on the line, in the cold bend test at 40°F., by 300 to 500 per cent.

Conclusions

Reviewing the evidence, thus presented, we find that:

1. Coal-tar enamel of the original type, properly used, has a known service record of 46 years in continuous use, and the enamel in this case would have lasted many years longer if kept in service.

2. The newly developed improved coal-tar pitch enamels are the equal of the old type in resistance to deterioration from water penetration, and therefore will have as long a life under submersion.

3. The improved type coal-tar pitch enamels are greatly superior to the original type in physical and performance characteristics.

4. The improved type coal-tar can withstand considerable abuse, as evidenced by the abrasion test, the results noted in the San Gabriel Dam No. 1 outlet lines and the results of the collapse in the Bouquet Canyon pipe line.

In the evidence, thus presented, too, may be found the answer to the question "How long will it last?" On this evidence the bureau bases its belief that the improved coal-tar enamel, when properly applied and installed, will give a permanent protection to its steel water lines.

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Concrete Coating for Underground Piping

By J. Herman T. McGee

IN DISCUSSING concrete for underground pipe line protection, it is first necessary to analyze the conditions that make this protection mandatory in many localities. Pipe line corrosion may result from several causes. Electrolysis from stray electric currents is one of the more commonly known attacks, but, as is well known, most engineers have learned to cope with this ailment, mainly by cathodic protection. A more serious offender, for which the solution is particularly difficult, is soil corrosion.

In numerous localities throughout the world there are what are known as "hot spots" where soil corrosion is active in varying degrees. In Florida, and particularly in the southern part of the state and along the coastline, where the muck areas are high in acids and in moisture content and where the texture of the soil permits the tides to percolate freely to and fro across the pipe lines, a real problem—a problem that has caused untold damage and expense in repairs and replacements—is caused by the corrosiveness of the soil.

In the town of Everglades a most unique condition exists. As the entire town was pumped up from the tidal marshes and the bay, the muck soil is very high in acids and of a texture that permits the small grains to set up actual batteries which generate an electric current that flows along the pipe in a very irregular manner. When this current leaves the pipe, carrying the iron ions with it, the real attacks occur. This iron is deposited in the soil, causing iron oxide, or rust, to form on the pipe. The currents do not leave the pipe uniformly due to resistances met in the film coats of paint or oils applied at the factory. The film, however, is very thin; and, intended only as a shipping protection, it soon becomes soluble and dissolves or is destroyed in other ways. The voids in the soil offer resistances to the flow of current; and as the current follows the line

A paper presented on May 16, 1940, at the Florida Section Meeting, Jacksonville, Fla., by J. Herman T. McGee, Engineer, Everglades, Fla.

of least resistance, it flows only where the soil touches the pipe. In Everglades, however, there are but few voids.

The first warning of the effect of the Everglades soil on the water mains was a geyser on one of the main streets in town. The break was repaired but the next day another geyser appeared. When a third break occurred, a thorough inspection was made. The pipe was found to be very soft and highly pitted. Most of the breaks were about $1\frac{1}{2}$ to 2 in. in diameter (Figs. 1 and 2), and the pipe near them was so soft it could be cut with a penknife (Fig. 3). Several joints were uncovered and found to be heavily pitted.

FIG. 1. Typical Blowout

FIG. 2. Typical Blowout Hole

D. Graham Copeland, Chief Engineer and General Manager of the Collier Interests at Everglades, communicated with the engineers of several cities in Florida, including Jacksonville, Miami and Tampa. Most of them replied that they knew nothing about the particular problem; and that they had neither experienced nor heard of anything like it. One stated that he did not believe cast-iron pipe could be cut with a penknife, regardless of its condition, so he was obliged with a sample on which to whittle in his spare moments.

Mr. Copeland then contacted Dr. K. H. Logan of the Bureau of Standards, Washington, and was successful in getting him to come to Everglades to help solve the problem. In the meantime, the staff exhausted all efforts to find data on the subject. Handbooks, textbooks and all sources that might be enlightening were consulted, but to no avail. Upon Dr. Logan's arrival in Everglades, an extensive

survey was made along the entire system—making test pits in every block. Using the excellent instruments furnished by Dr. Logan, it was found that the entire system was affected, the attacks growing in intensity as the line approached the river.

From the survey it was realized that some method must be employed immediately to prevent disaster. Replacing the entire line was out of question, so some method of protection had to be applied. Numerous concerns were consulted regarding the application of coatings that would assure complete protection. Very few data were available at that time, so several methods and materials had to be investigated. Progress was bound to be slow, however, because it was necessary to keep all the lines in service while the

FIG. 3. Pitted Pipe; showing holes cut with small penknife

treatment was being applied. Several offers to apply various materials were received, but no firm would guarantee its job. Dr. Logan suggested three methods that he thought might work. He was not sure of any of them, but thought a cement coating the best, and that was the method adopted because of the economy and high corrosion-inhibiting qualities of the cement.

The job, or at least a great part of it, had to be done during the rainy season; and the low lands required continual pumping because of the tides which percolated through the soil and filled the trenches. With cement, it was known that work could be started early in the morning as soon as the pipe line was out of the water, since the pipe would not have to be dry, as it would with other coatings. This resulted in an enormous saving in cost. In addition, the high

corrosion-inhibiting qualities assisted greatly in abating the corrosive action. In general, the pipe to be coated was not seriously weakened due to the depth of the pits. The job proved so successful, that Hollywood, Fla., used the same coating, with some minor variations, to meet its similar corrosion problem. In this paper, both jobs will be discussed together.

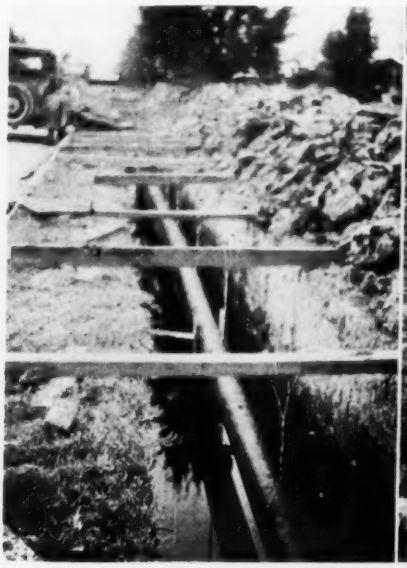


FIG. 4

FIG. 5

FIG. 4. General View of Pipe Swung in Trench
FIG. 5. Typical Forms for 6-Inch Pipe

Extent of Projects

In Everglades there were more than three miles of 4- and 6-inch mains laid in 1927–29 and in Hollywood, 3,665 ft. of 6-inch cast-iron pipe, installed in 1925.

In Hollywood, the first break occurred in 1927, with breaks increasing every year until the line was cement coated in the summer of 1939. Before coating, the line was breaking on the average of three times per week. Operations gave pressures of 40 to 45 lb. at the pump house on the beach. After coating, an average of 55 to 65 lb. pressure was maintained on this line continuously.

In addition, 1,650 ft. of cast-iron pipe laid on top of the ground,

in 1923, was afterwards covered with fill, dredged from North and South Lakes. Since the installation, fifteen breaks had occurred, and during the two years previous to coating, the number of breaks had increased. During the coating operation, it was necessary to replace approximately 400 ft. of pipe in the line; but since coating, no breaks have occurred.

In executing the coating process in Everglades, it was realized that the coating must be continuous, durable, and free of faults and cracks. In other words, a complete substantial coating around the entire pipe was necessary. With this in mind, it was decided to hang the pipe, with galvanized telephone wire, from timbers placed

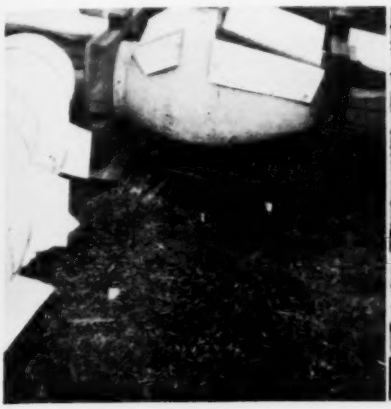


FIG. 6

FIG. 7

FIG. 6. Bell Forms for 6-Inch Pipe
FIG. 7. Forms in Place with Slater's Felt Lining

above the trench (Fig. 4). The movable forms were designed to cover the entire pipe and also to swing from the timbers above (Fig. 5). These forms consisted of 29-gage galvanized sheet-iron nailed to $\frac{3}{4}$ x $1\frac{1}{2}$-inch horizontal strips and so spaced as to give rigidity to the metal. Panels were made to fit between bells, and special bell forms were made to connect to the panels (Fig. 6). Wooden hinged collars were made to hold the forms in place, one being placed on either side of the bells and one at the panel's mid-point. Wedges were used to gage the forms evenly around the pipe. Strips, $\frac{3}{4}$ x 2 in., were nailed to the collars and to timbers above, thus holding the forms in place.

In Hollywood, a much heavier sheet metal was used, with set

screws so spaced as to give the proper clearance around the pipe. There, too, the joints were poured after the panels. A light slater's felt was used to line the forms (Fig. 7) to prevent the cement from sticking or adhering to the metal. The felt also served to seal the joints of the forms to prevent loss of cement, and acted as a moisture container until the trench could be flooded with water.

Coating Procedure

The pipe was uncovered, swung to the timbers and thoroughly scraped, cleaned and wire-brushed. An inspector, equipped with a pointed hammer, then tested the pipe to determine the amount of corrosion; and, in the test, several interesting conditions were dis-

FIG. 8. Dead Spots in Pipe; showing water bleeding through

covered. Most interesting, perhaps, was the bleeding pipe. For a distance of about 1,200 ft. the pipe pittings were not too serious, but a large number of dead spots had occurred on each joint of pipe, and in many of these spots, water bled through the pipe (Fig. 8). First, cast-iron plates were welded over these spots, but it was found that the process was both very slow and very costly. Therefore, it was decided to try cementing where the bleeding was slow enough for the cement to set without being affected by the water. This method proved highly successful—no breaks have occurred though pressures of 60 to 70 lb. have been maintained. The cement apparently adds strength as well as protection.

After the cleaning and brushing, the forms were set, usually about 500 ft. at a time. Cementing was the next procedure.

The ability of standard portland cement to meet the requirements of the particular case was questioned because of the possibility of its leaching out in the one-inch coating that was planned. A portland modified cement, containing a maximum of less than 8 per cent tricalcium aluminate, was recommended. This cement was developed on the Pacific Coast and is required by the specifications for highway, paving and other projects, being used to a large extent in Boulder Dam and at Lake Okeechobee. It was particularly

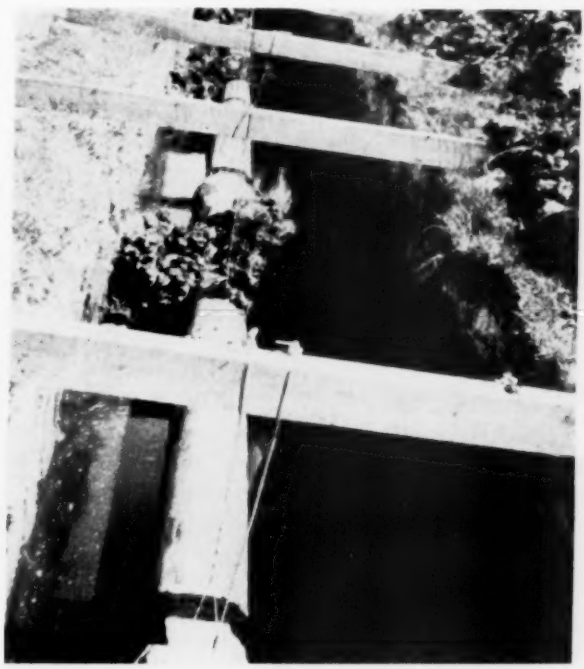


FIG. 9. Finished Coating Ready for Backfill

fortunate that the requirements of the Everglades and Hollywood projects could be filled from the Lake Okeechobee supply, through the Florida Portland Cement Company, as the cement sets more quickly and has a finished texture that makes it highly resistant to attacks by leaching.

With one problem solved, there was still the question of proper aggregates, as there was available a fine bay sand that was pumped up several years prior to the time of the work. This sand was thoroughly washed by the rains and was found to be extremely clean.

The laboratory at Gainesville recommended a mix of one part cement to two and one-half parts of sand. In Everglades, however, several local tests proved that mixes up to one part cement to four parts sand could be used successfully. The mixes actually used depended on the condition of the pipe, varying from 1:2½ to 1:4. Mixes were changed only when a different one could be used for a profitable distance. Water was controlled to give a consistency that would flow around the pipe with slight tapping of the forms. The cement was permitted to set over night. Forms were then removed and an inspector made a careful check of every foot of the coating for any type of flaws, honeycomb or spalls that might have occurred in removing the form. The results have proved to be almost perfect.

Trenches were flooded with water immediately after the forms were removed and on the following morning they were filled to the top of the pipe with soil backfill. This was left to settle and more fill added, being tamped thoroughly until all settlement had apparently ceased. The wires were then cut, the timbers removed and the backfill completed. Settlement of the pipe has been found to be nil.

In general, the same procedure was utilized over the entire line. Each year since the project was completed, test pits have been dug along the line to ascertain the general conditions. In these pits the cement is broken to check on the pipe and to see the exact condition of the coating. Also in making extensions to the lines, the department has had further opportunity to check conditions. In every case the pipe and the cement have been found to be in excellent condition—the cement showing no signs of leaching after six years in service.

Cost

The cost of the Everglades job was about 40 cents per foot of pipe. This figure includes total cost of forms, all labor, materials of every kind, moving grass sod, moving trees, equipment, etc. The cost may seem rather high, but when the low country and the rainy season, that caused a tremendous amount of pumping to keep the trenches dry, the moving of a large number of trees that were unknowingly set over the line in previous years and numerous other items are considered, it will be seen to be more or less economical.

At Hollywood, 3,665 ft. of 6-inch cast-iron pipe were treated with a 1-inch cement coating at a cost of 50 cents per foot; and 1,650

ft. of 8-inch cast-iron pipe, with a 1½-inch coating, with reinforcements using a 2 x 2-mesh, No. 14 gage wire, at 79.4 cents per foot.

Development of Factory-Applied Cement Coating

Even though cast-iron pipe has been accepted the world over due to its long life qualities and economy of installation, the manufacturers have realized that a protective coating of some kind must be employed in many localities such as Everglades and Hollywood where the soils are so vicious in their corrosive attack that the life of the pipe is reduced to the unbelievably short span of seven or eight years. In view of this situation, the American Cast Iron Pipe Company has made extensive studies and investigations, has conducted numerous experiments with various coatings, and has developed a factory-applied cement coating. This coating is applied under pressure using aggregates selected to give a dense and strong coating designed to bond thoroughly to the pipe. A tough fabric reinforcement is used on the exterior to prevent cracking, chipping or flaking of the cement in handling. The cement is omitted from the bell and the spigot end for about twelve inches to allow sufficient space for making up the joints after the pipe is laid. Several methods can be used for pouring these joints but each must provide a complete coverage around the entire pipe.

The coefficients of expansion of cast-iron and cement are practically the same; thus there is little danger of the bond between the two materials loosening due to expansion and contraction. A considerable quantity of factory-applied coated pipe has been shipped as far as Hawaii without injury to the coating in any instance.

The author has tested this coating in a small way by attempting, without success, to crack or flake the cement by pounding it with a heavy hammer. The cement was cut into with an axe and was found to be extremely hard, durable and of excellent adhesive quality.

In view of the unusual conditions that exist in the soils in Everglades, a test pit has been installed there to extend over a period of twenty years or more. Every two years a set of specimens with several different coatings will be removed for testing.

The author wishes to thank Messrs. Dickey and Bullock, both of Hollywood, Fla., for furnishing the data on the Hollywood project, and the American Cast Iron Pipe Company for data relative to factory coating.

Organizing for Community Defense

By Harry E. Jordan

AT VARIOUS times in recent years, spectacular disasters have led cities to establish community "emergency organizations." Certain Pacific Coast cities, for example, have set up plans for handling the situation resulting from earthquakes. Upon the assumption that large groups of residences might be demolished and numbers of the citizens would have to be served in concentration areas, plans for such emergency procedures have been developed.

Employees of public service departments are assigned to specific special duties. Sources of available water supply are listed as well as other information necessary if a large mass of people, detached from their ordinary routines, are to be cared for.

Likewise, following the 1937 Ohio Valley floods, experiences in certain cities led to the development of plans to handle the needs of the people whenever similar conditions occurred. The Eastern seaboard hurricane of 1938 also was the background of development of emergency plans in those areas.

Today the cities of North America face the need for organizing to meet that indefinable type of disaster called sabotage. The form of organization and the plans developed actually are a cross section of the plans proposed to care for people following earthquake, conflagration, flood or tornado.

They visualize the destruction or inability to serve of any or all public utilities. They contemplate the possible need for handling large numbers of people in emergency shelter areas and furnishing them food, water and other necessary comforts for living.

One large city has recently developed an army corps form of organization to function under such circumstances. The organization chart is shown herewith. The method of proceeding to develop such an organization was described in the News of the Field Section of the JOURNAL for September. Portions of that statement are repeated here.

"Any municipal executive—water supply, electric service or other chief—can call together the heads of the city's public services and say to them, 'We are facing certain conditions that make it important for us to get together and plan the way to take care of our people if something puts some one of our services under a handicap. Most of us are thinking about the war and the possible sabotage of our property. If that is what it takes to make us think about emergency or disaster service, then let's plan things from that viewpoint. Cyclones, earthquakes or floods can upset things for all of us and we ought to plan for them. But perhaps we can plan against sabotage or war and in that way know how to think about our common problems.'

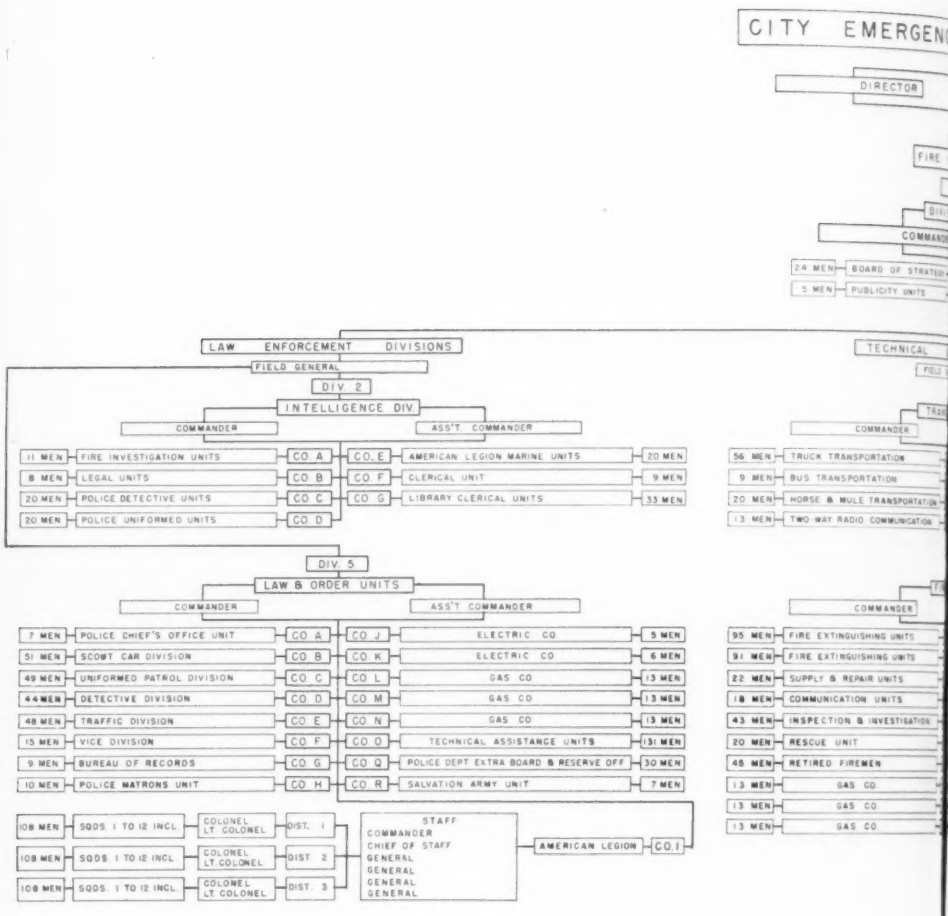
"By this time we should visualize that around the table are seated the heads of the city's fire, police, street and sewer departments. Along with them are the men who direct the water, electric, gas, telephone, street car, and similar services. And in due course of time, one of them says to the group, 'Our job is to work with each other and plan how we will take care of our people if the main water pumping station is out of service—if the key electric generating station cannot operate—if the city's transportation services are not available.

" 'As far as sabotage is concerned, our first job is to check our own personnel. Our next job is to report to each other any suspicious individual or act which might affect the service of any of us—then we need to organize to render some type of emergency service if the citizens remain in their homes or if large groups of them have to be moved to a concentration area.'

"Then the group should gather daily at first—later weekly—until they have satisfied themselves that they have done the best job possible. As far as the water works man is concerned, he will have developed a list of emergency private sources of drinking water, a way to be sure that the water can be made safe to drink, the assurance that some type of power will be available to pump the water, and he will have organized the emergency crew to handle the job.

"There is a wise newspaper man in every town who can counsel the group, advise them what to publicize and what to keep to themselves. And he should be the kind of man who will not try to scoop the other papers, for he will understand the situation."

Guidance may be had from experts of the Federal Bureau of Investigation although it should be recognized that demands upon that organization are unprecedentedly heavy.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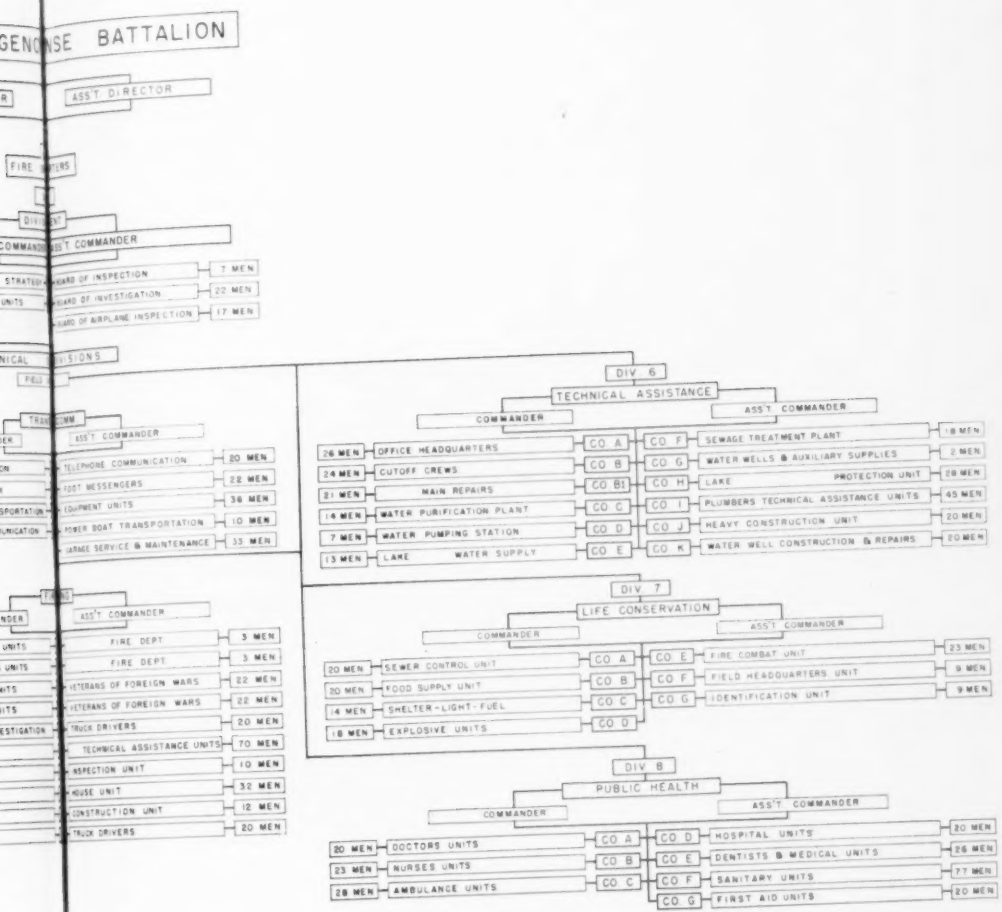
LAW ENFORCEMENT DIVISIONS
FIELD GENERAL
DIV 2
INTELLIGENCE DIV.
COMMANDER
ASS'T. COMMANDER
11 MEN FIRE INVESTIGATION UNITS CO A
8 MEN LEGAL UNITS CO B
20 MEN POLICE DETECTIVE UNITS CO C
20 MEN POLICE UNIFORMED UNITS CO D
CO E AMERICAN LEGION MARINE UNITS 20 MEN
CO F CLERICAL UNIT 9 MEN
CO G LIBRARY CLERICAL UNITS 33 MEN
DIV 5
LAW & ORDER UNITS
COMMANDER
ASS'T COMMANDER
7 MEN POLICE CHIEF'S OFFICE UNIT CO A
51 MEN SCOUT CAR DIVISION CO B
49 MEN UNIFORMED PATROL DIVISION CO C
44 MEN DETECTIVE DIVISION CO D
48 MEN TRAFFIC DIVISION CO E
15 MEN VICE DIVISION CO F
9 MEN BUREAU OF RECORDS CO G
10 MEN POLICE MATRONS UNIT CO H
CO J ELECTRIC CO 5 MEN
CO K ELECTRIC CO 6 MEN
CO L GAS CO 13 MEN
CO M GAS CO 13 MEN
CO N GAS CO 13 MEN
CO O TECHNICAL ASSISTANCE UNITS 131 MEN
CO Q POLICE DEPT EXTRA BOARD & RESERVE OFF 30 MEN
CO R SALVATION ARMY UNIT 7 MEN
108 MEN SQDS. 1 TO 12 INCL. COLONEL LT. COLONEL DIST. 1
108 MEN SQDS. 1 TO 12 INCL. COLONEL LT. COLONEL DIST. 2
108 MEN SQDS. 1 TO 12 INCL. COLONEL LT. COLONEL DIST. 3
STAFF
COMMANDER
CHIEF OF STAFF
GENERAL
GENERAL
GENERAL
GENERAL
AMERICAN LEGION CO I
TECHNICAL
COMMANDER
56 MEN TRUCK TRANSPORTATION
9 MEN BUS TRANSPORTATION
20 MEN HORSE & MULE TRANSPORTATION
13 MEN TWO WAY RADIO COMMUNICATION
COMMANDER
95 MEN FIRE EXTINGUISHING UNITS
91 MEN FIRE EXTINGUISHING UNITS
22 MEN SUPPLY & REPAIR UNITS
18 MEN COMMUNICATION UNITS
43 MEN INSPECTION & INVESTIGATION
20 MEN RESCUE UNIT
48 MEN RETIRED FIREMEN
13 MEN GAS CO.
13 MEN GAS CO.
13 MEN GAS CO.


BATTALION
ASST DIRECTOR
BOARD OF INSPECTION
7 MEN
BOARD OF INVESTIGATION
22 MEN
BOARD OF AIRPLANE INSPECTION
17 MEN
ASST COMMANDER
TELEPHONE COMMUNICATION
20 MEN
FOOT MESSENGERS
22 MEN
EQUIPMENT UNITS
36 MEN
MOTOR BOAT TRANSPORTATION
10 MEN
GARAGE SERVICE & MAINTENANCE
33 MEN
ASST COMMANDER
FIRE DEPT
3 MEN
FIRE DEPT
3 MEN
VETERANS OF FOREIGN WARS
22 MEN
VETERANS OF FOREIGN WARS
22 MEN
TRUCK DRIVERS
20 MEN
TECHNICAL ASSISTANCE UNITS
70 MEN
INSPECTION UNIT
10 MEN
HOUSE UNIT
32 MEN
CONSTRUCTION UNIT
12 MEN
TRUCK DRIVERS
20 MEN
DIV 6
TECHNICAL ASSISTANCE
COMMANDER
ASST COMMANDER
26 MEN OFFICE HEADQUARTERS CO A
24 MEN CUTOFF CREWS CO B
21 MEN MAIN REPAIRS CO B1
14 MEN WATER PURIFICATION PLANT CO C
7 MEN WATER PUMPING STATION CO D
13 MEN LAKE WATER SUPPLY CO E
CO F SEWAGE TREATMENT PLANT 18 MEN
CO G WATER WELLS & AUXILIARY SUPPLIES 2 MEN
CO H LAKE PROTECTION UNIT 28 MEN
CO I PLUMBERS TECHNICAL ASSISTANCE UNITS 45 MEN
CO J HEAVY CONSTRUCTION UNIT 20 MEN
CO K WATER WELL CONSTRUCTION & REPAIRS 20 MEN
DIV 7
LIFE CONSERVATION
COMMANDER
ASST COMMANDER
20 MEN SEWER CONTROL UNIT CO A
20 MEN FOOD SUPPLY UNIT CO B
14 MEN SHELTER-LIGHT-FUEL CO C
18 MEN EXPLOSIVE UNITS CO D
CO E FIRE COMBAT UNIT 23 MEN
CO F FIELD HEADQUARTERS UNIT 9 MEN
CO G IDENTIFICATION UNIT 9 MEN
DIV 8
PUBLIC HEALTH
COMMANDER
ASST COMMANDER
20 MEN DOCTORS UNITS CO A
23 MEN NURSES UNITS CO B
28 MEN AMBULANCE UNITS CO C
CO D HOSPITAL UNITS 20 MEN
CO E DENTISTS & MEDICAL UNITS 26 MEN
CO F SANITARY UNITS 77 MEN
CO G FIRST AID UNITS 20 MEN

The Public Administration Service, 1313 East 60th St., Chicago, has prepared for sale a bibliography on "Administration and Organization in Wartime in the United States."

Below will be found a bibliography of some of the articles on emergency procedures which have appeared in the JOURNAL in recent years. Further data will be furnished on request made by responsible water works executives.

One thing is certain. The present international situation is such that intelligent planning to meet major emergencies is needed. It is hoped that those who hold positions of responsibility will make use of the information available to them.

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Present Status of Cross-Connection Control

By E. Sherman Chase

IN 1932, at the Memphis Convention, the Committee on Cross-Connections presented an exhaustive report which was published in the JOURNAL for March, 1933. A second short report was published in the December, 1934, issue, but since that time, the Committee has made no formal report.

In view of the fact that the subject of cross-connections has been of interest to water works men and health officials for many years and because much has already been written on the subject, little need be said at this time as to the hazards involved in cross-connections of unsafe private supply with public supply. It should be noted also that this paper is confined to those cross-connections between two sources of supply and not the so-called "backflow" connections of plumbing and other interior equipment with water pipes.

The purpose of this paper is to present an accurate summary of the present status of the regulation and control of cross-connections by the various states and to present certain significant information which has become available since the last published report of the Committee on Cross-Connections. A detailed review of the subject has not been attempted as such a review would involve a repetition of much of the data already in print. In view of the fact that some of the data were received too late to permit the preparation of a report which could be circulated to the committee members for comments, it should be borne in mind that the author, alone, is responsible for all opinions expressed herein, except, of course, those which are quoted.

Early in 1939, a questionnaire was sent to each of the state sanitary engineers, requesting information upon the following matters:

1. Regulations governing the installation, operation, inspection and testing of cross-connections.

A paper presented on April 22, 1940, at the Kansas City Convention by E. Sherman Chase, Consulting Engineer, Metcalf & Eddy, Boston.

2. Progress in the enforcement of such regulations.
3. Experience with installations of double check valves.
4. Experience with backflow from overhead storage tanks on private systems into public mains.

Replies were received from each of the 48 state health departments—a noteworthy response, indicating the cooperative spirit of the state sanitary engineers.

To bring the 1939 data up to date, follow-up letters, asking for information as to changes since the earlier questionnaire, were sent early in 1940. Replies have been received from all but one state.

To give in detail all the information received would result in an unduly long paper and would add little to the subject. There are, however, certain interesting and worth-while data and comments which may well be presented for the benefit of the Association. Excerpts from the replies from certain of the states are as follows:

California—C. G. Gillespie:

"There are no regulations here; but inasmuch as water systems are subject to the State Water Systems Act which requires permits, issuable on such bases as the State Board of Public Health decides; and inasmuch as we have a great many supplies to be certified for use on common carriers and subject to the restriction, imposed by the [U. S.] Public Health Service, that certification is not to be granted if there are unsupervised or unacceptable cross-connections, it has followed that our policy is not to issue permits in cases where there are unsupervised cross-connections. The process, however, is mainly an educational one and is making good steady progress. I should add that very few water works voluntarily conform to the permit application feature of the Water System Act, but whenever they do, the above policy holds.

"Our principal device for overcoming cross-connections is by the use of double-check-valve installations. The Bureau has a layout which it describes as the minimum that will be acceptable, but it encourages water departments to go as much further as they can in getting greater perfection. Probably the largest instance of the use of double check valves is in the City of Oakland, where there are something like 400 installations. Periodic and careful check-ups were made about every three months, but the experience with back leakage has been so good that now the checkups are made about a year apart."

Illinois—C. W. Klassen:

"We do not have any printed regulations concerning cross-connections, but this department does not sanction nor approve any physical connection between the potable water supply and a supply which is either contaminated or subject to contamination. When a cross-connection exists, for example, between a municipal and a safe private supply, it is with the thorough understanding that the municipality is likewise carrying the responsibility for any pollution which might occur in the private supply, and where such conditions do exist these supplies are periodically sampled along with the municipal supply.

"When cross-connections involving a hazard to the water supply exist we, of course, do not approve the supply and many of the Illinois water supplies are watering points for common carriers; and without complete approval, water cannot be placed on trains for drinking purposes. This has likewise been a tremendous lever in the elimination of cross-connections."

Indiana—B. A. Poole:

"You will observe we still recommend double gate and double check valves in the case of cross-connections involving secondary ground water supplies. In adhering to this standard, we realize we are out of line with a good many state sanitary engineering departments who insist that there be absolutely no cross-connection.

"If we felt we could enforce a requirement which permitted no cross-connection between the public supply and a secondary ground water supply, we would certainly adopt such a regulation since we realize even the best gate and check valve will occasionally leak.

"Our experience has been that we cannot depend upon maintenance men, particularly in the larger establishments where there is a good deal of piping, to keep the two water supplies separate. Managers or supervisors can lay down rules that there be no cross-connection, but in the majority of instances a careful survey will reveal several connections. Because of this, we are of the opinion that the possibility of two check valves leaking simultaneously and permitting water from a secondary supply to enter public water supply mains is more remote than the possibility of the lines becoming tied together in the supposedly separate systems. Only time will tell which line of reasoning is correct.

". . . the tests of the past sixteen months show only one instance where both check valves were found leaking. We feel this is a pretty good record. We believe the records of the Connecticut Department of Health indicate equal results.

"Under our present requirements valve installations are tested semi-annually by water departments and the results submitted to this Bureau. In the case of smaller water departments where the results of the tests are apt to be questionable, our own men are able to check the valve installations. With existing personnel it would be impossible for our own men to make a thorough piping survey even once in two years. For this reason we believe our controlled check valve installations are providing more protection than would be provided if we had a non-enforceable regulation which permitted no cross-connections."

Mr. Poole wrote again this year, in part, as follows:

"The cross-connection control work in Indiana, insofar as regulations and requirements are concerned, remains unchanged. We have accumulated more data here in Indianapolis which indicates that a properly installed double gate and double check valve installation offers reasonable protection against leakage.

"Our engineers who devote their time to public water supplies have done considerable work on cross-connections in other sections of the state, particularly in our Calumet District. As a result of this we have more cross-connections under control than we had a year ago, although we certainly make no claims of having Indiana's cross-connection problem solved.

"The cross-connection problem which concerns me the most at the moment is not on the supplies now connected but on those which are not connected. By this I mean the industry which maintains a dual water system, and by so doing maintains potential cross-connections. If you really pin a factory manager down, he will tell you that he will cross-connect the two systems if the necessity for so doing arises. In other words, he will not shut his plant down because of failure of a pump motor or because his private water supply fails to furnish a sufficient amount of water. We consider such cases potentially dangerous. However, our existing cross-connection rule does not cover them. For some time we have given serious consideration to a revision of the rule so that we would be able to require protective devices on all public water supply service lines

which enter establishments that are equipped with secondary water supplies. I am reluctant to revise the rule in this manner for two reasons. First, administration of such a revised rule will be more difficult; and, secondly, the preponderance of expert opinion in the United States seems to be in favor of dual systems rather than cross-connected systems with protective valves on the public water supply service lines. Regardless of these two reasons I still do not feel absolutely safe where dual water supplies are found."

Iowa—A. H. Wieters:

"This cross-connection regulation has been in effect some ten years and the progress in eliminating cross-connections has been very gratifying. We feel that a great majority of the major or dangerous cross-connections in the state have been eliminated. A new factor which in the past few years has caused us considerable difficulty is the very greatly expanded use of water from private wells for air-conditioning purposes.

"We have never approved installations of double check valves and consequently have had no experience with reference to such installations and their maintenance.

"About a year ago we had an outbreak of gastro-enteritis in a small community of 3,500 population, where the incidence of the disease was in excess of 75 per cent of the population. After a careful investigation of this epidemic, we came to the following conclusion:

"The ordinary source of water supply for the town is a deep-well supply which is pumped by deep-well pumps to a surface reservoir, from which it is repumped into the system. An old standby pump, called a fire pump, which was in place only for extreme conflagration, took suction from this surface reservoir and also suction from the adjoining river. This pump had not been used for several years because the emergency had not existed. However, because of this connection, this Department refused to approve the supply.

"During some reconstruction in the plant, the water in the elevated tank became nearly depleted while some change-overs were made in the piping, with the result that the operator became concerned and filled the elevated tank from the clear water surface reservoir utilizing the large capacity emergency fire pump which was also cross-connected with the river. The valve on the river suction line evidently leaked, with the results above mentioned.

Fortunately, there were no cases of typhoid fever. I am simply citing this as an example of the human equation, where physical conditions are such that cross-connection is possible."

Kansas—Earnest Boyce:

"There has been a rather interesting extension of inspection work in connection with the inspection of water supplies for interstate carriers for the U. S. Public Health Service. Prior to this year, as far as Kansas is concerned, the investigation has been limited to the source of supply and the quality of water at the source of supply. At the request of the Public Health Service, this service now includes inspection of the water handling facilities, including hose valve boxes, hose storage, and many other details.

"In this connection we discovered the existence of a contaminated water supply in one of the principal watering points of one of the main lines crossing Kansas. This contamination was checked in every way possible to determine its location, and it was finally found that a sewage sump pump in the basement of the station had a prime line directly connected to it, and that this prime line was open causing the contamination that was being noted in the coach filling lines. Our intention is to indicate a rather definite extension of the cross-connection investigational work carried on by this department."

Maine—Elmer W. Campbell:

"It will be noted that the regulations contain no provision as to quality of the supply cross-connected. Paragraph 2 specifies simply 'private water supply system' and requires elimination of the connection or proper protection. This permits no tolerance of unprotected cross-connections nor does it limit the water supplies that may be cross-connected when properly protected.

"These regulations have been in effect nearly eight years. Previous to their adoption, representatives of water utilities, industry, and the state department of health held numerous conferences and the subject was given much publicity among those concerned. Emphasis at that time was on auxiliary supplies for fire protection and process water at factories. With the adoption of the regulations, the cross-connections of that type were rapidly eliminated or provided with proper protection.

"The regulations place the responsibility for reporting the existence

of cross-connections on the private concern or individual owning the connection. They are likewise made responsible for the monthly inspections and maintenance. With the passage of time, the initiative in the making of monthly inspections has been largely assumed by the water utilities. An employee of the utility is usually assigned the duty of inspecting the registered cross-connections with representatives of the owners at a certain time each month. Under this system the inspections and reports to this office are generally faithfully made. When necessary, notification from this office that a report is overdue brings prompt attention.

"Since the first years of regulation, the reporting of unprotected cross-connections by owners has practically ceased, possibly due in large measure to failure to understand what constitutes a cross-connection. The water utilities occasionally report unprotected cross-connections and seek their elimination or protection. But the initiative in discovering unregistered and unreported cross-connections is at present largely taken by the state. Engineers from this office make such investigations as time permits. A few cross-connections are discovered each year and steps taken to have them eliminated or protected.

"Resort to court action to enforce the regulations has never been taken. The necessary changes have so far been accomplished by persuasion backed by the existence of the regulations.

"Double check valves of the so-called 'Factory Mutual' approved type have been used in Maine since 1931. Each installation is inspected for tightness monthly by representatives of the owners and the public water utility supplying service. Semi-annual inspections are made by engineers from the Division of Sanitary Engineering of the State Bureau of Health.

"The valves have been installed under varying conditions of use. Many are on service lines through which water is used constantly, or frequently, for manufacturing purposes. Others are on lines providing fire protection only and are subject to almost constant back pressure. Our experience seems to indicate that those valves on lines through which water is frequently drawn are in a better position to remain satisfactory than those on static fire lines. Valves on lines subject to only infrequent use and especially those valves subjected to almost constant back pressure in excess of that of the public supply have been found, on being internally inspected, to show a greater tendency toward rough seats and rubbers. This is probably

due to the rubber facings being pressed firmly against the seats for long periods. Since most water supplies in Maine are of a corrosive nature, there is a tendency for rust scale to accumulate in lines through which little water is drawn. This increases the chances of the checks being held open enough to cause leaks."

New Hampshire—Leonard W. Trager:

"In the course of a number of years we have found that the local water departments are rather lax in making the periodic inspections as required by law, and that many of these have to be made by this department if they are to be made at all. The writer has personally made a large number of such inspections, and has found, in the cases where the old iron-body 'Factory Mutual' check valve had been installed, it was not unusual to find that one of these check valves proved to be leaking. On the other hand, however, the writer has never found one case where the leakage occurred in the newer type of all-bronze, so-called 'Uniflow,' check valve type, except in one instance where the rubber disc had to be renewed—the leakage in this case being only slight.

"Relative to overhead storage tanks, I had a rather unusual experience at one time, where the overhead tank at a greenhouse was used for a steepage tank—the water to be applied to the plants and flowers for a quick fertilizer. In this tank there was dumped a number of loads of manure and it was filled with water from the bottom. Simultaneously with the filling of this tank, the mains in that section of the city were shut off temporarily by the water department. When this occurred all the water from this manure steepage tank was drained back into the system, causing, of course, severe contamination of the mains."

New York—C. A. Holmquist:

". . . we wish to point out that cross-connections between two water supply systems are permissible when *both* supplies are of safe potable quality and when the auxiliary supply is subject to routine supervision by the local water officials, and information is available that the auxiliary supply is of safe potable quality. The retention of such connections, therefore, must be based upon approval by the local water officials, in accordance with the provisions of Regulation 2 of the State Sanitary Code.

"In further reference to the above reply, we wish to point out that

fire-pump chlorinators of a special design have been accepted by this Department in specific instances when their proposed installation has been subject to review by the Department and the local water officials, and the installation has been approved. Under these circumstances the auxiliary water supply would be subject to heavy chlorination at doses of either 2.5 or 5.0 p.p.m., whenever the fire pump chlorinator is operated either automatically or manually. As a required additional safeguard, double all-bronze check valves of approved type must be installed on the connection to the potable water supply system. These check valves and the fire-pump chlorinator must be subject to routine supervision and periodic testing, records being maintained on appropriate blanks and submitted to the Department for review at monthly intervals. The selection, as to which of the two heavy doses of chlorine, noted above, must be used in specific instances, is made by the Department, when the installation of a fire-pump chlorinator is being considered. This dose, of course, will be based upon the degree of pollution of the auxiliary supply being chlorinated. There are times of course when the degree of pollution of the auxiliary supply is such that chlorination cannot be relied upon, in which case approval of a fire-pump chlorinator installation would be withheld.

"Satisfactory progress has been made in the enforcement of Regulations 2 and 3 of Chapter V of the State Sanitary Code. Obviously cross-connections are being discovered from time to time by local water officials or representatives of the Department, following which corrective measures are taken without delay. In many instances, elimination of cross-connections has been made possible by the use of elevated tanks into which water from the potable supply would be discharged through an above-water connection, through which non-potable water could not enter the potable water system.

"Double check valves such as described above in connection with fire-pump chlorinators are not approved in the absence of such chlorinators. In other words, use of a fire-pump chlorinator, if approved by the Department and the local officials, is equivalent to changing the non-potable supply to a potable supply, in which case a cross-connection would be permissible, not because check valves were used, but because the auxiliary supply is chlorinated. The existence of check valves alone on cross-connections between potable and non-potable supplies, however, would not comply with our regulation.

"Check valve installations used in connection with all of the fire-pump chlorinators installed in New York State have been inspected from time to time by representatives of this Department, representatives of the fire underwriters and local officials, in addition to the more frequent inspection by those in charge of the installation. Insofar as inspections by representatives of this Department are concerned, we have found quite a number of installations where at least one of the two check valves leaked to a noticeable extent. In only two instances, however, did both check valves leak at the same time when tested; and in these instances the units were not being properly supervised and foreign material was allowed to accumulate in the valves.

"We might note at this point that the control of cross-connections in New York State has lead to the eradication of outbreaks of water-borne diseases incidental to the passage of polluted water through cross-connections into potable water supply systems. Previous to 1928, a number of serious water-borne outbreaks were due to this source of pollution of potable supplies."

Ohio—F. H. Waring:

"In 1939, this department investigated the discharge into a large public water supply system, of untreated water by an industrial concern. It was found that a single check valve separating the public supply from the industrial source of supply did not function. The factory supply, normally, or during week days, had a pressure below that of the city. However, during week ends, that is, Saturday afternoon and Sunday, when plant processes were shut down, water from the polluted source, through automatic pumps, rose in an elevated tank to a point such that the head developed was in excess of the city pressure. Flow of the untreated water, therefore, was into the city system. Prompt inoculation of all persons residing in the section of the city affected probably prevented an outbreak of water-borne disease."

Rhode Island—Charles L. Pool:

"Cross-connections here are hard to find, that is, we have reached the stage where the program of control requires vast activity per new correction. Also, we have a lever, to secure corrections, which has not been generally appreciated, even locally. A state law administered by the Department of Labor requires safe water for in-

dustrial employees, and naturally if there is a cross-connection, their water is not safe and it can be required that the connection be corrected."

Washington—R. M. Harris:

"In one installation of double check valves it was found that pieces of bark had lodged under the seat of both valves simultaneously and allowed leakage to exist.

"Our greatest difficulty in preventing the installation of cross-connections, and in eliminating existing cross-connections, lies in the rather accepted practice of cross-connecting salt-water fire-protection systems to fresh water lines supplying mills."

Wisconsin—L. F. Warrick:

"The provision of our Water Works, Sewerage and Refuse Disposal Code is as follows: 'Auxiliary intakes, bypasses or cross-connections, whereby polluted water may be pumped or allowed to flow into the distribution system of any public supply, under any conditions, will be prohibited except under the following special conditions:

" '(a) An existing intake or bypass may be maintained providing a section of the pipe is removed to be reinserted only in case of emergency, and immediately issuing notice to consumers to boil all water used, and notifying the Board by wire.

" '(b) In new supplies, auxiliary intakes or bypasses may be permitted by special approval of the board if satisfactory reasons are set forth as to the necessity therefor, and installation made in accordance with (a) above.

" '(c) An existing cross-connection for fire protection purposes only, which was originally installed before January, 1924, may be continued if protected by approved types of double check and gate valves, equipped with suitable gages and drains for testing, and on condition that monthly inspections of such equipment are made and reported upon by the owner of the public supply on or before the tenth of the month. The Board reserves the right to require elimination of any cross-connection, if inspections are not regularly made and reported upon, or if the connection is found faulty. All cross-connections, other than those used only for fire protection purposes, shall be eliminated. New cross-connections are prohibited. Permission to maintain any existing cross-connection for fire protection

purposes must be obtained from the board on or before January 1, 1930.'

"A comprehensive state-wide survey, to locate and either eliminate [cross-connections] or secure installation of suitable protection facilities, was started in 1929, the cooperation of the water works superintendents being obtained in making the monthly inspections of those fire protection cross-connections permitted under the code provisions. Our district engineers and local health and plumbing officials have been called upon to carry out various phases of the program to properly safeguard public supplies against the hazards of cross-connections. A special bulletin on this subject was prepared and distributed throughout the state, . . . which has been most helpful in educating officials and the public to the importance of properly taking care of this problem. Since the work was inaugurated, in 1929, there have been no epidemics of water-carried diseases in Wisconsin that have been traceable to cross-connections. Excellent co-operation has been afforded by officials and individuals concerned in carrying out our cross-connection elimination or protection program.

"The type of double check valve installation is shown on the report form. . . . Leakages have occurred, according to our tests, but if the facilities have been properly installed and are periodically inspected, we have considered these hazards to be reduced to a minimum. The last epidemic due to a cross-connection in this state was in a situation where a single valve had been placed on an emergency connection, made in an industrial plant between a public water supply distribution system and a boiler feed water supply, the source of which was a polluted stream. This epidemic is described in an article entitled 'Safeguarding Wisconsin's Water Supplies' (Jour. A. W. W. A., **22:** 516 (1930))."

Interpretation of Replies

The replies showed clearly the variety of policies pursued by the different state health departments. Many states have no specific regulations governing cross-connections, but nearly all make some attempt to control them either under specific regulation or under broad general powers.

Table 1 summarizes, as accurately as possible, the writer's interpretation of the present status of cross-connection control in the United States.

A few states have reported in detail the results of inspections of check valve installations. These states are Connecticut, Indiana, Maine and Massachusetts. The results of their tests are summarized in Table 2.

The *Health News*, of the New York State Department of Health, for March 4, 1940, refers to a decision of the Supreme Court of Mississippi confirming an award of $3,000 to cover damages for injuries resulting from the alleged pollution of the public water supply of Cleveland, Mississippi, by a dangerous cross-connection.

TABLE 1

Cross-Connection Data

ITEM	NO. OF STATES REPORTING
Definitely established rules and regulations relating to cross-connections	26
Cross-connections controlled under general powers	22
Character of control in enforcement:	
(1) Good	26
(2) Fair	15
(3) Poor	7
Experience with double check valve installations:	
(1) No experience or none reported	28
(2) Generally satisfactory	12
(3) Definitely unsatisfactory	4
(4) Detailed and accurate records	4
Policy regarding double check valve installations:	
(1) Definitely disapproved or prohibited	18
(2) Permitted under special conditions	22
(3) Permitted with fire-pump chlorinators	2
(4) No expressed policy	6

A contractor laying a concrete pavement obtained the water necessary for construction from the public supply through a fire hydrant connection. Eventually, the contractor's pipe, leading from the hydrant to the point of construction activity, was also connected with a pump taking water from a polluted creek. The pump built up pressure in excess of that in the public main, and localized

pollution of the public supply followed. This resulted in an outbreak of acute gastro-enteritis which affected 157 of the 355 people in the area surrounding the hydrant.

Several of the state sanitary engineers referred to the hazards involved in the so-called "backflow" in plumbing systems. This type of hazard is one to which the committee on cross-connections

TABLE 2

Results of Inspections of Double Check Valve Installations

DATE	INSTALLATIONS	INSPECTIONS	LEAKING VALVES			BOTH VALVES O.K.
			One		Both	
			Inside	Outside		
Connecticut—State Department of Health						
Jan. 1927 to July 1938	161	6,823	122	17	7	6,677
Type of Valve						
Iron body	110	4,653	98	14	6	4,535
All bronze	48	2,056	10	2	0	2,051
Small brass	3	114	14	1	1	98
Indiana—City of Indianapolis						
Feb.–Mar., 1938	131	—	16		1	114
Sept.–Oct., 1938	140	—	10		0	130
Jan.–Feb., 1939	139	—	1		0	138
Maine—State Department of Health						
1934–35	112	1,261	4		—*	1,257
1935–36	113	1,337	3		—	1,334
1936–37	113	1,271	6		—	1,265
1937–38	109	1,156	3		—	1,153
Massachusetts—State Department of Public Health†						
1938	596	415	44		2	369
1939	722	789	105		19‡	665

* Only one case in all four years where both valves were leaking.

† Water departments also make inspections.

‡ Three-inch or less, except two 4-inch and one 8-inch installations.

has called attention in the past, but which is outside the scope of the committee activities.

None of the state sanitary engineers had had experience with backflow from private elevated tanks, although Trager's account of the steepage tank is indicative of what may happen.

Mr. Poole of Indiana suggested it might be well to provide double check valves on pipes leading into industrial plants having dual water

supplies. No general policy in this connection has as yet been adopted and Mr. Poole is the only state sanitary engineer to mention it.

A second problem, for which satisfactory policies have not as yet been worked out, relates to cross-connections with presumably potable but unsupervised private supplies. This problem appears to be particularly acute in Indiana, Illinois and California, although it probably exists in many other states.

None of the engineers, in their replies, referred to the desirability of installing proper double check valves, or other protective devices, on water mains leading into sewage treatment plants. It is, however, the practice in some states to require some form of protection. This is a practice which should be adopted to prevent the possibility of contamination of the public distribution system through unapproved "backflow" within the treatment plant itself. Probably this particular problem is one for the Committee on Distribution System Safety.

Conclusions

From the review of the data obtained from the state sanitary engineers, the following conclusions have been drawn by the author:

1. Only about half the states have rules and regulations dealing specifically with cross-connections.

2. Practically all state health departments, however, maintain some degree of control of cross-connections, acting under their general powers when specific regulations are lacking.

3. In only about half the states can the control of cross-connections be characterized as good.

4. Over half the state health departments have had no experience with double check valve installations, usually because such installations are prohibited or disapproved in those states.

5. Health departments in the industrial states appear to be somewhat more willing to permit double check valve installation, under special conditions, but in New York and Tennessee, fire-pump chlorinators are also required. Generally *new* cross-connections are not permitted, even with double check valves.

6. About one-third of the health departments definitely disapprove or prohibit all cross-connections, including those equipped with double check valves.

7. Experience with the modern all-bronze double check valves,

properly installed and supervised, has indicated relatively little hazard of contamination through them.

8. Need exists for the more general adoption of regulations governing cross-connections.

9. Regulations should be based on the principle that an enforcible regulation accomplishes more than an ideal but non-enforcible prohibition.

10. Regulations should attempt to:

(a) prevent new cross-connections;

(b) eliminate existing cross-connections wherever possible and in the shortest practicable time;

(c) permit continuation of existing cross-connections only in special cases where their elimination would work an economic injustice or replace one hazard to life by another;

(d) require such cross-connections, as are permitted to remain in existence, to be made only by means of all-bronze double check valve installations which are properly installed, regularly tested, periodically and thoroughly inspected and cleaned or repaired when necessary.

11. Consideration should be given to the problem of industrial plants having dual water supplies, even where the two supplies are presumably separated; and to the problem of cross-connections of presumably safe private supplies with public supplies.

12. Water works and health department officials should co-operate in the detection and elimination of cross-connections, and to this end, adequate funds and personnel should be provided.

The author gratefully acknowledges the splendid co-operation received from all the state sanitary engineers. He also wishes to point out that this paper is presented at this time in lieu of a committee report, in order to give the membership the benefit of current factual data at an earlier date than would be possible were such data kept for the forthcoming committee report.

Water Quality Standards

By John R. Baylis

IN 1914, the Public Health Service of the United States Treasury Department (now under the Federal Security Agency) adopted a standard of quality for drinking water served on common carriers engaged in interstate commerce. This proved to be the most important step ever taken to insure the delivery of safe drinking water by water works to the public. The adoption came at a time when the public health officials of some states were considering standards of quality as a guide for requirements of the water in their states. Some of them at that time already were exercising considerable authority over the quality of the water.

Although only a minor amount of the water used for drinking and culinary purposes came from the common carriers, the standard was believed to be a good one and similar standards of quality were quickly adopted by the health departments of the various states. Not many water works officials objected to the requirements, and most of them began voluntarily to comply with the standard if they were not already doing so. Where compliance was not voluntary, pressure from the state department of health generally resulted in at least some improvement.

The first standard adopted by the U. S. Treasury Department was never intended to be applied universally, and it was not too well suited for this purpose. In 1925, it was revised to make it more rigid. Although the committee drafting the revised standard stated that the recommendations applied only to supplies of drinking water offered by common carriers for the use of passengers carried in interstate traffic, and were not proposed for more general application, it was, nevertheless, realized that the revision would serve as the standard for all public water supplies in the United States. In general, water meeting the bacteriological requirement of this stand-

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ard is reasonably safe for drinking. Within the past few years, however, several outbreaks of diseases, usually transmitted by water, have occurred in cities supplied with water meeting the standard; and this has created doubt about its ability to insure safe drinking water under all conditions. Probably as a result of this, and from the realization of the imperfections of the present standard, a new standard is soon to be adopted by the U. S. Public Health Service. The new standard will quickly be applied all over the United States, and it should be written specifically with that realization in mind. Many water works men are already wondering if it will be made more rigid and what other requirements it will impose.

Present Standards and Their Limitations

Those engaged in the purification of water are familiar with the provisions of the standard adopted by the Treasury Department on June 20, 1925. The standard is divided into three sections: (1) source and protection; (2) bacteriological quality; and (3) physical and chemical characteristics.

In practice, the bacteriological quality is the only provision given much consideration. Water testing well within the bacteriological requirement usually is approved, although other qualities may not be so good. With bacteriological quality doubtful, defects in the system, or other qualities of the water sometimes are given consideration. The bacteriological quality should, of course, receive greatest consideration, though it should not be the sole criterion for acceptance of the water.

The word "shall" is used in the bacteriological requirements, and "should" is used for stating the physical and chemical properties the water should meet, except that, "where such analysis shows the presence of lead (Pb), copper (Cu), or zinc (Zn), in excess of the limits specified in Appendix IV, this *shall* constitute ground for rejection of the supply."

The main requirement for bacteriological quality is that not more than 10 per cent of all the standard (10 ml.) portions examined shall show the presence of coliform organisms. This requirement is qualified by the statement that occasionally three or more of the five equal (10 ml.) portions of a single standard sample may show the presence of coliform organisms. The percentage of the samples which may show this number of coliform organisms is limited to 5 per cent when twenty or more of the samples have been examined.

Nearly all of the water treatment plants are averaging so much better than this standard in coliform organisms that it is believed the freedom from water-transmitted diseases in our cities can be attributed more to this fact than to the adequacy of the standard. A water purification plant which now averages more than one-fifth the number of coliform organisms allowed by the standard is regarded a poorly operated plant. Most of the plants do not average one-tenth the number allowed. Notwithstanding all this, there are a few who would oppose making the standard more rigid.

Since a new standard is to be adopted, would it not be wise for the committee drafting the revisions to look into the future and begin making departures from existing requirements for water quality—departures aimed at insuring the delivery of safer water, and departures which will give encouragement to those who now are striving to operate their systems in the most efficient manner possible? Changes somewhat along the lines to be suggested seem essential if we are to progress in water quality to the state where transmission of disease by water is a thing of the past.

Need for More Extensive Federal Control

A roadside eating place on a heavily traveled highway may serve drinking water to a greater number of people in one day than the "Twentieth Century Limited" will serve in several days or a week, and there are many more eating places than railroad trains. The travel by auto and by bus has become so great that those eating and drinking water at a well-patronized eating place in one day include travelers from many states. All eating places, and all gasoline stations having drinking water available, therefore, should be placed on the same basis as common carriers in regard to the quality of the water served. If Mr. Smith lives in Illinois and wishes to take a trip to Pennsylvania by auto or bus, he will most likely pass through the states of Indiana and Ohio; and he is entitled to just as much protection in regard to his drinking water in passing through these states as if the trip were made by train.

There is as much justification for federal jurisdiction over the water served in eating places and gasoline stations as there is upon trains. This raises the question of the advisability of giving control of the quality of all water for drinking and culinary purposes to the U. S. Public Health Service. Control which would involve more direct approval than at present of water supplies as to source of

supply, adequacy of the system, and approval of plans before extensions or additions to the system may be made. The writer believes that such control eventually must come. Fast methods of travel have almost obliterated state lines, and the sooner we accept this fact and adopt uniform means of safeguarding health throughout the nation, the more rapid progress will be.

This is not a recommendation that the departments of health of the various states be superseded, but that they operate more fully under federal regulation in matters pertaining to water quality. The U. S. Public Health Service could formulate the rules, and the states would be expected to enforce them. It is believed that a plan, whereby there would be full co-operation between the state and federal employees could be worked out.

Another reason for believing that extension of federal supervision of water quality is desirable is that in some instances enforcement of sanitary measures by the health departments is not as thorough as it should be. This lack of enforcement is not neglect of duty on the part of the state sanitary engineers, but rather is caused by lack of sufficient rules and power to enforce the rules, and to the lack of a large enough personnel. The head of the health department in each state is usually an appointed officer, who, sometimes, is limited in his activities. Good rules, therefore, are occasionally not strictly enforced. Pressure from federal health officials to force improvement in design and operation of water works has so far been quite meager. Usually the federal authorities are content to let go by all that the state departments of health let go by, sometimes knowing that not as much has been done as should be to make the water safe.

In some states the rules of the state department of health are not being followed as thoroughly as they should be by a few of the water works, so it is difficult to regard such rules as giving the protection they should. To illustrate, construction of a filtration plant is now under way in one of our cities without approval of the plans by the state department of health. Similar instances have happened in other places. Is there a state in the union where a city could be prevented from constructing a filtration plant because plans were not approved by the state department of health, if the city officials cared to ignore the health department? Could the city be prevented from supplying water to the inhabitants from such a plant, if the water meets the present bacteriological standard, although the plant contains many health hazards? If the answers to these questions

are "No," is not public health protection on a somewhat shaky foundation?

Rules under which a public water supply may be built should be such that attempts not to give full consideration to health protection in the design and operation of a water works would be greatly discouraged. Perhaps the laws should be so strict that wilful violation of health rules, either in design or operation, would subject the violator to prosecution and punishment commensurate with the offense.

Need for More Rigid Requirements

Since nearly all public water supplies are now delivering water of a bacteriological quality much better than that of the present standard of the U. S. Public Health Service, there is no way of telling if water just passing the standard is safe. Supplies regarded as just meeting the standard generally average better than the standard most of the time; and the periods in which they just meet the requirements are from a few days to a few weeks during the year. This being a fact, many believe the present standard is rigid enough to insure the delivery of safe water. In most places, where the treatment works are adequate and where those in charge are given support to operate the plant at a high state of efficiency, good operators will maintain a quality of water far superior to the standard if it is possible to do so. There still are a few places, however, where the management of the water works does not appreciate as fully as it should the importance of an adequate and well operated system, and resents efforts by health officials to have the system and its operation improved.

In order to force into line some few indifferent water works officials, the writer believes that the standard of the U. S. Public Health Service should be made broader in scope, more specific, and more rigid in bacteriological quality. The adequacy of the water system from source of supply to the consumers taps has a definite bearing upon the quality of water delivered to the consumer. The method of handling emergency conditions is an important item often overlooked. The operating personnel has much to do with insuring safe operation. These items should be given more prominence than heretofore, and the only way to give them prominence is to have minimum standard requirements for them as well as for the bacteriological content.

Desirability of a Grading System

Is it not time to begin injecting into the standards a system of grading or scoring for public water supplies? Public health officials already have the authority to take into consideration features of a water system other than the bacteriological quality, but little power of enforcement. The plan should be extended into a real grading system. It is realized that a few will object to grading water supplies, yet there is sufficient evidence of the value of grading systems in other industries and lines of endeavor to justify its consideration. Schools and colleges use a system of grades whereby there is a minimum requirement for the student to pass, and grades to indicate the general standing of the student. The best students makes grades much higher than the minimum.

Water purification plant operators often receive little encouragement to produce water better than that of the standard, and sometimes are denied money to purchase additional chemicals, or to improve the treatment plant or other parts of the system on the grounds that the water already passes the requirements. Believing that the present is an opportune time to begin giving consideration to measures which will encourage the production of water of a quality as near perfect as it is feasible to make it, the writer should like to make a few comments on possible ways in which this can be done.

Proposed Plan for Grading

A system, somewhat along lines already proposed by several authors, in which many features of the system influence the grade, might be extended into a suitable method of grading. There should be at least four and perhaps five divisions in the system, and the water should be graded in each division independently of the others. The four divisions recommended, in order of their importance, are:

1. Bacteriological quality.
2. Adequacy of the system,—such as source of supply, treatment works, pumping stations, distribution system, and other parts of the structure.
3. Personnel.
4. Chemical qualities,—including turbidity, taste, odor, and the chemical constituents of the water.

The suggestion has been made that a fifth division, called "emergency control," be added to the list. This may be of sufficient im-

portance to separate it from the division on "adequacy of the system." Whether or not it is included in a separate division, it is of major importance and should greatly affect the grade of the division under which it is included.

Letters or numbers may be used in the grading system. The writer believes that letters would be better for the grades in the four or five main divisions. Numbers may be better for the various items included in a division. Assuming 100 a perfect score, Grade A should represent a score between 90 and 100; B should be between 80 and 90; C, between 70 and 80; D, between 60 and 70; and E, below 60.

Grade D water would be considered just passing the requirements for drinking and culinary purposes. Any water supply having Grade D water should be required to obtain a permit to continue operation, and this permit should be subject to renewal every six months, or every year. The water should be considered of a quality, or likely to be of a quality, below that which should be supplied to the consumers. There should be constant urging on the part of the health officials to have the system improved. The health department should have the power to revoke the permit at any time deemed advisable, although there may not be a depreciation in the bacteriological quality of the water or other features of the system at the time the permit is revoked.

Grade C water should be considered the minimum under which a water system is allowed to function without improvements being urged by the health authorities.

Grade B water should be the minimum aim of every water system, and those responsible for the operation and maintenance of the system should not lessen their efforts toward improvements until the water meets the requirements for this grade.

The hope of every one operating a water system should be eventually to supply Grade A water. There are some sections of the country where this may not be possible with the sources of water available. Where a system can meet the requirements for Grade A water, there is no reason why it should not be given such a grade to encourage its keeping the system up to this state of perfection.

Over 90 per cent of the amount of water now being supplied to the inhabitants by public water supplies can be made to meet the recommended bacteriological requirements for Grade A water. A large percentage of the water already meets this requirement; and a number

of water supplies not now meeting the recommended requirements for Grade A water can do so at small extra cost.

To be considered suitable for drinking and culinary purposes, water should have to pass the bacteriological requirement, certain chemical requirements, and all parts of the system should meet some minimum requirement regarded as adequate to insure the delivery of safe water to the consumers. The person or persons operating each part of the system should be competent and well trained and there should be a definite plan for meeting emergencies. The water should be classified according to the lowest grade it receives in any one of the four or five divisions. The grade of each division should be decided upon after consideration of the grade of each item of the division. One important item not up to standard may cause the entire division to be classified below requirement. To illustrate, a cross-connection to a polluted supply may be considered so dangerous that it is given a grade below the minimum requirement. This in turn would set the grade of the division relating to the adequacy of the structure, which would cause the water to be given Grade E.

Grading Bacteriological Quality

The bacteriological quality may be classified somewhat as shown in Table 1. There may be objection by many to the inclusion of 37-degree counts on agar and of the presumptive tests for coliform organisms. Coliform organisms themselves are not harmful, but their presence indicates the possibility of the presence of disease-producing bacteria, though in a much smaller number than the coliform organisms. Any organism forming gas on standard lactose broth also may indicate possible pollution, and while the danger may not be so great if these organisms are not coliform, they most likely are not without some significance. The belief is that when the positive presumptive tubes are greater than twice the number of completed tubes they should be given more consideration than the coliform organisms. There may be question as to the advisability of including presumptive tests and counts in Grade D water.

The table takes into consideration 100-ml. portions as well as the 10-ml. portions. Whether the water works should be expected to use both quantities in their tests is doubtful. The time has come when larger amounts of water should be tested than has been the practice heretofore, whether it be done by increasing the number

of 10-ml. portions, or by using larger portions of a sample. In a water works where the number of positive presumptive 10-ml. tubes do not exceed more than one to two per cent of the total number of tubes inoculated, 100-ml. portions would enable larger portions of the water to be tested without adding greatly to the laboratory work. There is evidence that a smaller index of coliform organisms is obtained when 100-ml. tubes are used than with 10-ml. tubes. The cause for this is not known, but there seems to be sufficient evidence to state that it is a fact. For this reason, the suggested bacterial requirement based upon testing 100-ml. portions is more rigid than it is for 10-ml. portions.

TABLE 1

Proposed Bacterial Grades
Based Upon Monthly Averages

GRADE	FREQUENCY OF SAMPLING	BACTERIA PER ML. 37°C. AGAR	PER CENT OF 10-ML. BROTH TUBES POSITIVE		PER CENT OF 100-ML. BROTH TUBES POSITIVE	
			Presumptives	Completed	Presumptives	Completed
	hr.					
A	6	4	1	0.5	7.5	3.7
B	6	10	2	1.0	15	7.5
C	24	20	10	5	50	30
D	24	50	20	10	75	50

There should, of course, be provision for an occasional sample in which three or more of the five 10-ml. portions show the presence of coliform organisms.

There may be question about bringing back into the standards the count on agar at 37°C., for many believe that the number of bacteria is without significance. The writer, however, is inclined to believe that the total number of bacteria may have some significance and should not be ignored entirely. The number of bacteria now present in the water in most public supplies is quite low and any system meeting the requirements for coliform organisms usually will not have difficulty in meeting the recommended requirements for total number of bacteria.

Frequency of Sampling: The frequency of sampling as suggested in the table should be the minimum for a water supply to receive the grading indicated, except that very small supplies may be sampled less frequently. This system of sampling pertains to the water

leaving the treatment plant or the place where it is chlorinated before being delivered to the distribution system. In addition to sampling at the treatment plant, samples should be collected daily from locations on the distribution system. The writer, in an article recently published (*Water Works and Sewerage*, **86**: 96 (March, 1939)), made the following suggestion in regard to number of samples to be tested:

"There should be at least ten 10-ml. tubes of lactose broth inoculated with the finished water every day in small water systems, and at least forty 10-ml. tubes inoculated in large cities. At least two samples of the finished water should be collected twelve hours apart for bacterial tests in small plants, and not less than four samples collected six hours apart in large cities. The samples in large plants preferably should be collected every four hours, which would give six samples daily. Inoculating five 10-ml. tubes from each sample would give 30 tubes daily for six samples, none too many for good control of the purification process.

"In addition to samples collected at the purification plant, samples should be collected from points over the distribution system. There should be daily collection of samples from at least five points over the distribution system in all cities over 25,000 inhabitants, and from at least ten points in cities over 500,000 inhabitants. Small cities may confine the distribution samples to two or three. At least two of the samples should be from the outer extremities of the distribution system, where it is believed the water is longest in the system. A material increase in the number of bacteria in the distribution system should cause the system to be promptly investigated."

The frequency of sampling and the number of sampling points recommended in this article are none too frequent and none too many. Hourly sampling and inoculating 100-ml. portions of the water being delivered to the distribution system would be a good plan for plants of moderate to large size.

Grading the Adequacy of the System

Not much will be said about the adequacy of the system, for it is too broad a subject to discuss in detail and many are more capable than the writer to discuss it. All will agree that the supply should be sufficient in quantity to meet the need of the consumers, and that the works be so constructed that a sufficient quantity of water at reasonably constant pressure be maintained throughout the distribution system. Cross-connection to polluted supplies should be pro-

hibited. The fixtures in homes and other buildings should be such as to avoid contamination. All water, regardless of source of supply, should be treated with some kind of sterilizing agent such as chlorine. Where the water is polluted, such as that from streams or any other surface source of supply, it should be filtered. The filtration plant should be adequate to purify the water properly; and any objectionable quality of the water should be removed or corrected.

In giving a grade to the adequacy of the system, many items have to be taken into consideration, and much thought will be required to work out a system upon which to base the grade.

Often not enough consideration is given to the importance of constructing a water system wherein the pressure will be off, or below normal, at rare intervals. Cutting off the pressure of the water on a section of the distribution system is a serious health hazard because of the danger of contamination getting into the pipes. Fire insurance companies have done much more than health officials to insure adequate and constant pressure on water distribution systems, whereas the health officials should take the lead.

A water works system should be required to keep a record of pressures on the distribution system. Recording gages, which will show both pressure and vacuum, should be maintained at enough points to give a good idea of the pressure throughout the entire system. A record should be kept of all sections of the distribution system where the water pressure is turned off for repairing piping, and these records, together with a sketch showing the piping cut off, should be reported promptly to the state department of health.

Mains which have been opened for repairs should be chlorinated before being turned back into service. A cut-off section should be maintained in a cut-off state, except for one open valve to supply the section until tests on the water from consumers' taps indicate that the water is safe.

To safeguard health adequately, all consumers' services should be cut off from a section with pressure off as soon as is practical, and should not be opened until the pressure is on the line and a flow of water containing a liberal amount of residual chlorine is established in the mains. The consumers' services then should be turned on and all faucets allowed to run until there is residual chlorine at each faucet. Failure to comply with this precaution by a water works should cause the water to receive a low grade.

This specific item is mentioned to illustrate how a grading system

may operate to safeguard health. A water works may operate for years with the bacteriological samples testing almost perfect and the public may believe their water safe beyond question. Then, suddenly, the careless handling of a repair to the mains in some section of the city may cause an outbreak of some water-borne disease. Should a water works receive a low grade because of failure to observe adequate precautions in repairing and maintaining the system, this at least would let the public know that the system is being operated in a dangerous manner.

Standards for water quality should give specific rules to follow in safeguarding health in many items such as the one above mentioned. If such rules become a part of standards of the U. S. Public Health Service, state sanitary engineers should welcome such rules, and no doubt would see that they are followed, or at least grade the water in accordance with the degree with which they are complied.

In the present drinking water standards (under Appendix I) is given the scope of requisite information as to source and protection. This includes a sanitary survey, a description of the system, and the pertinent facts relating to the sanitary condition of the water supply. A number of items are listed in the general scope of the survey, but no attempt was made to give the weight these items should have in grading the supply. The intention was to allow the person making the survey to rely largely upon his own judgement as to the adequacy of the system. A system of grading would have to assign values to the various items of the water works. The section on the adequacy of the system would, therefore, have to be divided into sub-divisions, such as a source of supply, purification works, pumping stations, and distribution system.

Grading the Personnel

Another division difficult to grade is the operating personnel. Any plant receiving a poor grade because of its personnel will, most likely, claim prejudice by the grader. Although the grading may not be made perfect, it can detect gross indifference and inefficiency in operation. Training, experience, ability, and disposition should be taken into account. There should be a sufficient number of employees to operate the system, and to operate it efficiently. Licensing certain water purification plant employees is in practice in some states, and should be made universal, but while licensing corrects some abuses, it does not go far enough.

There should be the same number of grades for employees in responsible positions as grades in the other divisions. No water should be considered acceptable where the person in charge of the water works or the purification plant receives a grade below passing. Low grades for other employees should not cause disapproval of the water, but should cause its grade to be lowered.

TABLE 2

Proposed Chemical Requirements

SUBSTANCES	AMOUNTS NOT TO EXCEED				
	A	B	C	D	E
*Turbidity	0.2	0.5	10	100	over 100
*Odor or Taste Threshold	3	5	10	20	over 100
*Lead (Pb) *p.p.m.*	Trace	Trace	0.1	0.2	over 0.2
*Fluoride (F) *p.p.m.*	0.3	0.5	1.5	2.5	over 2.5
Color	5	7.5	10	25	
Total Solids	500	750	1000	1500	
Calcium (Ca) *p.p.m.*	50	75	100	150	
Magnesium (Mg) *p.p.m.*	50	75	100	150	
Sulfates (SO_4) *p.p.m.*	100	150	250	400	
Chlorides (Cl) *p.p.m.*	200	300	500	1000	
Copper (Cu) *p.p.m.*	0.2	0.2	0.2	0.5	
Zinc (Zn) *p.p.m.*	2	3	5	10	
Phenol, *p.p.m.*	0.000	0.000	0.001	0.002	
Iron (Fe) *p.p.m.*	0.1	0.2	0.3	0.5	
Manganese (Mn) *p.p.m.*	0.1	0.2	0.3	0.5	
Micro-organisms, *c.s.u.*	5	10	100	500	

* The water should not receive a grade higher than that of the grade given this item.

Grading Chemical Quality

Water should be less difficult to grade according to chemical qualities, for the chemicals present can be determined by tests. Once a system of grading is established, it would not be difficult to give the water its proper grade. The proposed chemical requirements are given in Table 2, which gives limitations for the several grades. Only four items are given a grade of sufficient importance for the particular item to cause the water not to be accepted. The list does not include all of the chemicals present in water.

The standard should state that any chemical present naturally in water in objectionable amounts, or a chemical added in objec-

tionable amounts, will decrease the grade of the water. If present in amounts sufficient to have a possible effect upon the health of those consuming the water or to cause the consumers not to use the water, the water should be disapproved. Copper will, most likely, never be present, naturally, in water in harmful amounts, yet it would be possible to add a harmful dose. Residual chlorine should not be present to the extent it will cause the consumers to seek drinking water elsewhere.

Federal and State Authority

The proposed extension of federal authority may receive opposition, for many believe we are getting along all right under the present division of authority. Nothing, which has been said about the failure, in some instances, of state officials to accomplish all that is desired, should cast reflection upon the efforts and ability of these officials. Some of them are operating under laws which do not give the state departments of health the authority they should have; and there does not seem to be much prospect of the strengthening of these laws within the near future. In correcting this defect, the federal government can give aid.

There may be argument that the present standards cover all the necessary details essential for safeguarding health. In a general way, this is a fact, but imagine trying to enforce the correction of sanitary defects in a water system through the authority granted by the present standards. There may be correction of some of the most dangerous defects, but there will be many places where potential sources of danger exist and where the water works will resent making the change—particularly if it is an expensive change. Leaving the adequacy of a system to the judgement of the person making the sanitary survey—with only vague rules to follow in forming judgement—leaves much to be desired. The present standards have been in force for about fifteen years, and not as much progress has been made in correcting health hazards in cities as there should have been. Where the water works officials oppose making changes, progress has been much slower. States frequently do not have the necessary experienced help to make a thorough survey and to follow up the survey to see that recommendations are carried out.

Correcting defects in structures already in existence is an unpleasant task, and frequently causes friction between the health department and the water works officials. To lessen such controver-

sies, public health officials let many things go by which should be changed. The time to correct defects in new structures, or in structures being remodeled, is before construction is started. A few of the designing engineers are not as considerate of the sanitary engineer as they should be in seeking advice about avoiding health hazards, and this will continue to be the case unless measures are taken to prevent it. As a result, the various parts of many water systems possess sources of danger. Most designing engineers welcome the advice of the sanitary engineer, and the more experienced they become in designing water works structures, the more anxious they are to have their designs reviewed by someone experienced in judging the sanitary safety of the structure.

Recommendations for strengthening the rules under which water works structures are designed and operated, therefore, do not strike at those who wish to do the right thing, but are aimed at the few who do not wish to follow what experience has taught to be the best means of safeguarding public health. Laws prohibiting construction or remodeling of existing water works structures without approval of public health officials would do much toward insuring properly designed structures. There probably are some states where sufficient authority exists to insure proper safeguards, but in many the authority either does not exist or is not enforced as strictly as it should be. Such a situation should not continue. Recently the remark was made by an engineer working on the design of a water works structure that the sanitary engineers were going "too far" and that they were "doomed for a fall." We know that this represents the feeling of very few water works employees. It should not represent the view of any one.

The writer is aware that all of the suggestions which have been made cannot be expected to be incorporated in a new standard at the present time. Much, however, can be done and should be done.

Discussion by *Harry E. Jordan.* * Those who are interested in the production of safe water supplies are greatly indebted to Mr. Baylis for this stimulating presentation. He has not only been responsible for a great amount of valuable research related to water treatment, but he has also not hesitated to interpret that research in terms of the highest ideals of water quality.

*Secretary, A.W.W.A.

Reference should be made to the paper by H. W. Streeter entitled "Standards of Raw and Treated Water Quality" (Jour. A.W.W.A. **31:** 1479 (1939). The opinions expressed by Streeter in many ways do not coincide with those expressed by Baylis. Neither statement is an official record or opinion expressed by the A.W.W.A. as an organization. Each, however, finds its place properly in a journal devoted to the advancement of the knowledge of water supply.

As Editor of this JOURNAL, as well as one having been associated with water supply activities over a number of years, the writer feels constrained to comment upon certain details of Mr. Baylis' paper.

In his third paragraph the statement is made: "outbreaks of diseases usually transmitted by water have occurred in cities supplied with water meeting the Standard." There is some difference of opinion about these cases and all persons who have examined the matter are not so positive as Mr. Baylis appears to be. At least, it appears not altogether well founded to predicate the case for revision of the 1925 Standard upon these outbreaks.

In the eighth paragraph of the paper we find: "A water purification plant which now averages more than one-fifth the number of coliform organisms allowed by the Standard, is regarded as a poorly operated plant." This appears to be an unnecessary chastisement of some of the operators or plants.

The observation may be made that the author tends to base his argument for a higher standard upon the reported ability of the average plant to "more than meet" the present Standard. That is hardly sufficient ground for change. It needs to be supported by data which set forth clearly the measurable gain in public health resulting from production of the higher quality supply. In this connection, it must be admitted that it has become quite difficult to develop contrasting public health data which make a case either for the present standard or its revision. In other words, annual records of typhoid fever and similar disorders show such low rates in American cities that it is hard to relate water supply quality to the frequency of the disorders.

The Association has for several years had an able committee, headed by G. D. Norcom, which is making an effort to obtain from state sanitary engineers the record of sporadic outbursts of disorders, which appear to be water-borne, along with records of the bacterial quality of the water at the time of the outbreak. The results are discouraging, for as yet very few such data have been developed.

On the other hand Scott of Connecticut has recently studied records of water supply quality in certain towns and he discloses the fact that in several instances, breakdown of equipment has resulted in deviations of water quality and the distribution of water having a coliform content much in excess of the Treasury Standard. No deviation in public health parallelled the deviations in water supply quality. We must grant the probability that deviations of similar magnitude on other supplies taken from highly polluted sources would be likely to cause sickness. The circumstance is related simply in contrast to some of the views expressed by Mr. Baylis.

Out of all this, we must develop a platform for whatever revision the U. S. Treasury Standard is to have. We must inquire what points of demonstrated weakness now exist and what requirements need to be set up to eliminate those points of weakness. This must be neither revision for revision's sake nor a "laissez faire" attitude. We are indebted to Mr. Baylis for stimulating our attention to this important matter.

Investigation of a Water Pressure Tank Explosion

By R. J. Karpen

ON DECEMBER 14, 1938, the water pressure tank of the municipal water supply of Bricelyn, Minnesota, exploded, wrecking the pump house and tank. The explosion occurred at 1:00 A.M. just as the pressure gage indicated a pressure near 60 pounds and the pump was about to be shut off. The possibility that the zinc lining in the pressure tank was a contributing factor to the explosion was indicated in an investigation conducted by the Minnesota Department of Health.

The Bricelyn water supply, prior to this explosion, was obtained from a drilled well from which the water was lifted by means of air and discharged into a small receiving tank. A centrifugal pump was used to force the water from the receiving tank into the pressure tank and distribution system. This pump had a rated capacity of 250 g.p.m., and was designed to operate up to a maximum head of 60 lb. per sq.in. It was the practice of the operator to maintain the water level in the tank about 4 in. above the center. This he accomplished by pumping at approximately two-hour intervals from 7:00 A.M. to 3:00 P.M., at 6:00 P.M., 8:30 P.M., and at midnight. The daily consumption of water was about 18,000 gal. The pressure tank, 8 ft. in diameter and 36 ft. long, had been in service for 36 years. It was provided with a pressure relief valve which when tested opened at a pressure of 66 lb. per sq.in.

Eight or ten months prior to the explosion, a leak developed in an end seam at the bottom of the tank. After the tank was drained and inspected, it was found that the portion of the tank which had been in contact with the water was pitted and corroded. It was then reconditioned by welding the defective seam and its interior surface was coated by spraying it with molten zinc. This zinc coating

A paper prepared by R. J. Karpen, Public Health Engineer, Health District No. 2, Minnesota Dept. of Health, Mankato, Minn.

varied in thickness from a few thousandths of an inch on the upper portion to approximately $\frac{1}{8}$ in. on the bottom or corroded portion. The tank was then placed back into service.

Thirty-four days later, the explosion occurred forcing off one end and moving the tank 5 ft. in the direction of the closed end. The zinc surface, after the explosion, was light grey in color, and when examined under a hand lens appeared to have a rough spongy surface.

Cause of the Explosion

Because of the extensive damage which resulted, it seemed highly improbable that the tank had burst by abnormal water pressure. Evidence indicating that an explosion and not abnormal water pressure disrupted the tank was that the air relief valve opened at 66 lb. and the pump had a maximum discharge pressure of 60 lb. It appears logical to assume that the pressure in the tank could not have exceeded the maximum pressure to any great degree before the air relief valve would have opened or the maximum discharge pressure of the pump would have been reached.

A consideration of these facts led to the theory that an explosive mixture of a combustive gas with the air normally present in the tank for pressure may have occurred and become ignited. A rapid explosion might also account for the fact that an abnormal pressure in the tank was not dissipated through the pressure relief valve.

The occurrence of methane gas in the water was among the first of the considerations undertaken in the investigation. A sampler of the type described by Buswell and Larson (Jour. A. W. W. A., **29:** 1978 (1938)) was constructed, and analyses were made of the samples of gas expelled from the water by heating. The results of these tests indicated that methane was not present in a sufficient quantity to build up an explosive mixture. This may also be corroborated by the fact that no other explosions had been known to occur in the tank.

The possibility of the zinc lining and water reacting to form hydrogen gas was then considered. With this in mind an analysis was made of the well water, and several experiments were performed. Table 1 shows the results of the water analysis.

As can be seen from Table 1, the well water is moderately hard and has a moderately high iron content. The dissolved oxygen content of the well water is 0.2 p.p.m. Since the air lift system is no longer in use it is impossible to determine the D.O. content of the

water after it is lifted to the surface with air. It would seem that the water would be saturated with oxygen. It might, however, have been possible for zones of exhausted or partially exhausted D.O.

FIG. 1. End View of Pressure Tank After Explosion

to have occurred within the tank. The pressure of oxygen in air is only $\frac{1}{5}$ of the total pressure of the air and the air bubbles would tend to be relatively large. Under conditions of low oxygen concentration, hydrogen is more readily liberated from solution.

The D.O. content of a sample of water collected from the present pressure tank was 1.9 p.p.m. With the present system, the water from the well is pumped directly into the pressure tank by means of a deep-well turbine pump. When the pump goes into operation, the air remaining in the piping at the end of the previous pumping is forced into the tank, and thus maintains the air pressure.

The carbon dioxide content of the water as determined from a chart using the pH and alkalinity values is 90 p.p.m.

The pH of the water was found to be 6.9. This would indicate a condition that would tend to be favorable for the production of molecular hydrogen at the surface of the zinc lining. This pH value,

TABLE 1

Characteristics of the Bricelyn Well Water

Total hardness, *p.p.m.*	240
Alkalinity, *p.p.m.*	370
pH	6.9
Manganese, *p.p.m.*	0.08
Iron, *p.p.m.*	0.6
Calcium, *p.p.m.*	64.0
Magnesium, *p.p.m.*	5.4
Temperature, °*F.*	48
B.O.D. (5-day)	0
(10-day)	0
CO_2 content of well water from pH and alkalinity values, *p.p.m.*	90
D.O. (well water), *p.p.m.*	0.2
D.O. (water in new pressure tank), *p.p.m.*	1.9

however, might not be a true representation of the pH of the water in the pressure tank. The aeration of the well water as it was lifted to the surface with air would have a tendency to reduce the carbon dioxide content, and thus increase the pH.

A qualitative analysis of the zinc lining indicated the presence of iron and nickel. Quantitative estimates indicated that these elements were present in quantities of less than 0.01 per cent. Hence they probably did not contribute materially to overcoming the protection of over-voltage on the surface of the zinc thus permitting the formation of hydrogen gas.

An experiment was conducted by suspending in a glass tube pieces of the zinc lining. The tube was filled with water from the Bricelyn

supply and inverted in a dish of water, thus confining the liquid by atmospheric pressure. At the end of several days, a considerable quantity of gas had collected in the tube, and when analyzed it was found to be hydrogen. This same experiment was conducted using water from other sources and similar results were obtained. Another experiment was conducted to determine the effect of pressure on the reaction. Accordingly, a small pressure receptacle was made up of pipe fittings and equipped with a pressure gage and air valve. Water and a piece of the zinc lining were introduced into the tank, and air was pumped in until the pressure reached 55 lb. After several days, a sample of the gas was drawn and analyzed in the laboratories of the school of chemistry of the University of Minnesota. This sample contained approximately 10 per cent hydrogen. The tank was then set aside at atmospheric pressure, and a month later it was found that the pressure had built up from 0 to 20 lb. per sq.in. Tests indicated that the gas causing the pressure was hydrogen.

The results of the field investigation and experimental data indicated that it was possible for an explosive mixture, of hydrogen and the air normally present in the tank for pressure, to have been produced within the pressure tank. If this did happen there is some room for speculation as to how the mixture may have become ignited. It could be that a water hammer produced in the system, possibly at a check valve, could have been sufficiently great to have forced, momentarily, the pressure in the tank to exceed 66 lb. and thereby to have produced an igniting spark at the air relief valve.

Water Supply at Akron

By the Akron Staff

ON THE following pages is presented a panoramic description of the Akron water supply. Each of the phases of its work has been reported by the member of the organization directly responsible. Organization of personnel is as shown in Fig. 1.

Following is an outline of the various sections and a list of the authors of the paper:

Part 1. Introduction—W. R. LaDue, Superintendent and Chief Engineer.

Part 2. Watershed and Impounding Reservoirs—J. S. Gettrust, Superintendent of Water Purification and Pumping.

Part 3. New Impounding Reservoirs—A. E. Goodman, Associate Engineer.

Part 4. Use of Surplus Lands—George Mitchell, Farm Overseer.

Part 5. Raw Water—Its Delivery and Treatment—C. O. Hostettler, Chemist.

Part 6. Pumping of Treated Water—F. M. Hinderschied, Plant Engineer.

Part 7. Delivery of Treated Water and Reconditioning of Force Main—L. W. Bausher, Junior Engineer.

Part 8. Repumpage to High Service Districts—J. Houston, Junior Electrical Engineer.

Part 9. Storage of Water—J. L. Gotschall, Assistant Engineer.

Part 10. Distribution of Water—F. D. Paul, Superintendent of Distribution.

Part 11. City Properties—F. Boekley, Distribution Supervisor.

Part 12. Service Permits and Meter Billing—H. J. Hazen, Supervising Account Clerk.

A paper presented on May 9, 1940, at the Ohio Section Meeting, Akron Ohio, by the staff of the Akron Bureau of Water Supply, under the direction of W. R. LaDue, Superintendent and Chief Engineer.

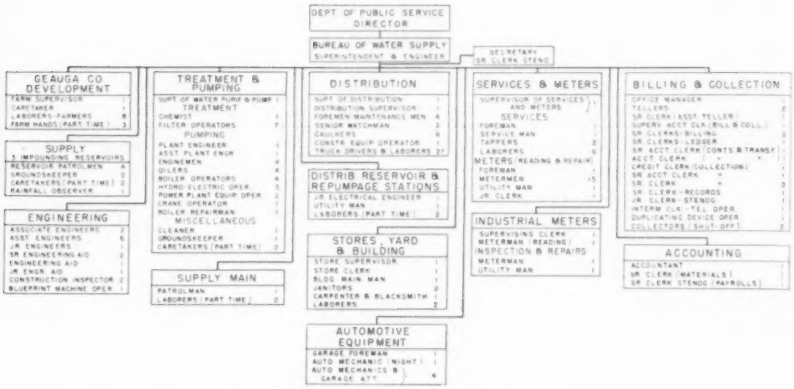
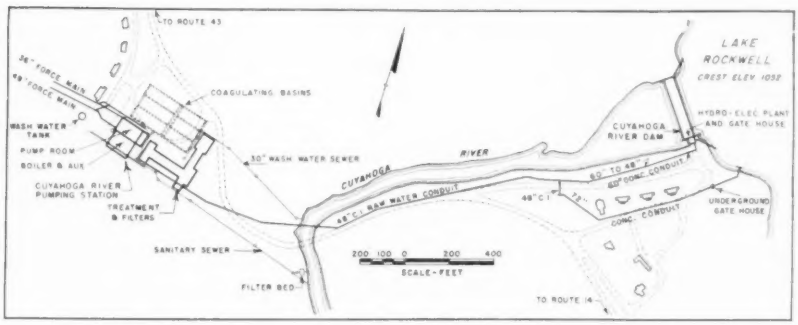


FIG. 1. Organization of Personnel



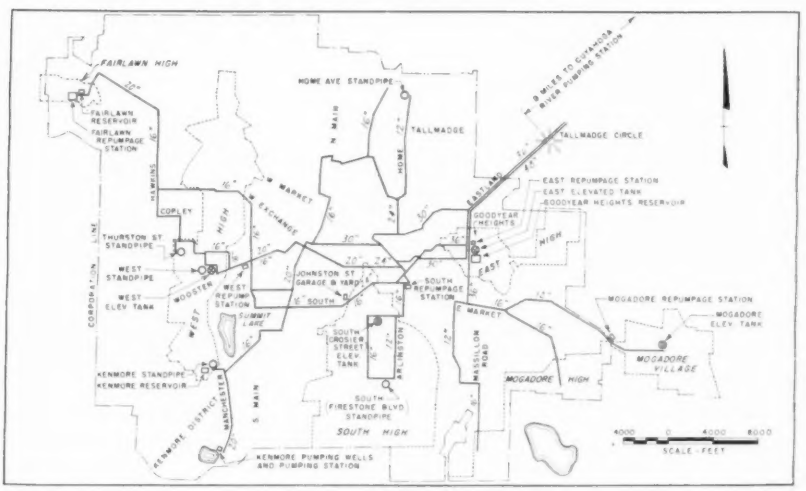


FIG. 2. Akron Water System

Part 13. Domestic Services and Meters—R. HANSON, Supervisor of Services and Meters.
Part 14. Industrial Services and Meters—L. OLSEN, Supervising Clerk.
Part 15. Collections—W. E. MYERS, Credit Clerk.
Part 16. Accounting—GEORGE HOGLE, Accountant.
Part 17. Office Practice—L. J. HOFFMAN, Office Manager.

Other members of the organization who were active in the preparation of this paper were: O. R. ELTING, Associate Engineer; E. MAY and E. C. SHELLENBERGER, Assistant Engineers; O. RHOADES, Garage Foreman; and E. STEWART, Store Supervisor.

EDITOR'S NOTE: This presentation of data concerning the Akron Bureau of Water Supply, organized under the direction of W. R. LaDue, Chief Engineer and Superintendent, is an admirable example of the type of personnel relationships established by Mr. LaDue.

At the time of the original presentation, each individual in the group was presented to the Ohio Section members by his chief, and, on his own behalf, presented a brief statement of the departmental activities under his control. As an example of visualization of team work, it deserves emulation by many water works men.—*Harry E. Jordan.*

1. Introduction

Public water supply for Akron had its inception in 1880 and 1881, when some 18 miles of mains and 600 services were installed by the Akron Water Works Company. The original source of supply was a large well located on the old pumping station grounds. As the growth of the city made additional water necessary, the original well was supplemented by driven wells and by water pumped direct from Summit Lake. Serious and continued complaints of poor quality and insufficient pressure resulted in the ultimate purchase of the plant by the city on April 1, 1912. At that time, Akron had a population of 82,000 and consumed water at the rate of 9.25 m.g.d. through 113 mi. of mains and 12,000 services. In 1915, the old supply was abandoned and the new Cuyahoga River supply put into service. The growth of the supply has kept pace with the threefold growth of the City since 1912, and has resulted in a business with an investment of $17,000,000 deriving an annual return of one

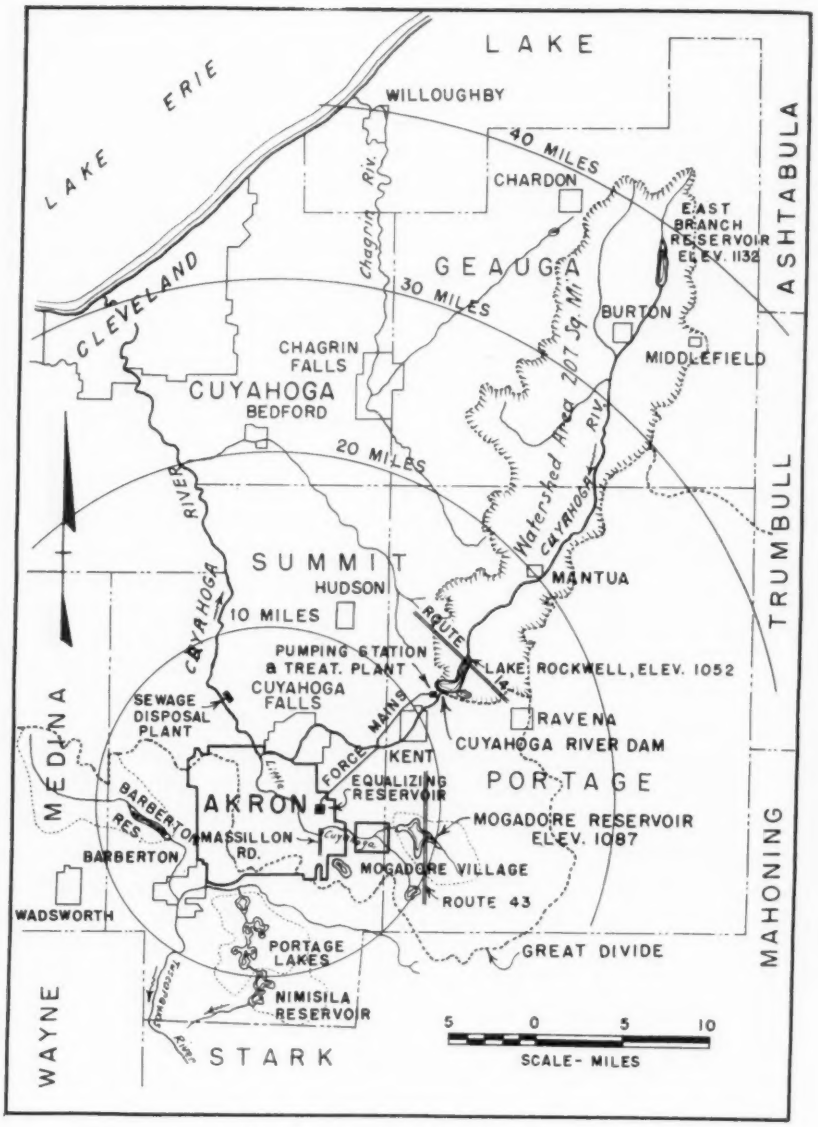


FIG. 3. Akron Water Supply

and one-third million dollars by serving 56,000 customers, or 240,000 people, with 22.5 m.g.d. through 645 mi. of mains.

2. Watershed and Impounding Reservoirs

The domestic water supply for Akron is derived from 207 sq.mi. of watershed in the upper Cuyahoga River valley in Geauga and Portage Counties, and is capable of supplying a sustained flow of 100 m.g.d. at the Lake Rockwell Dam. The present development, including the new East Branch Reservoir, will safely yield 37 m.g.d.

Lake Rockwell, the original impounding reservoir of the system, is formed by the Cuyahoga River dam, located about 2½ mi. north of Kent, Ohio. This dam, 280 ft. long, is of the hollow concrete type with crest elevation at 1,052 ft. above sea-level and 480 ft. above Lake Erie. The reservoir, with an available capacity of 2,300,000,000 gal. of water, covers some 770 acres to an average depth of 10 ft. Since 1934, flashboards have been placed on the crest of the dam each year, after the spring rains, and these raise the water surface 1½ ft., providing 400,000,000 gal. additional storage.

The watershed is predominately rural, there being but a few small communities such as Burton, Middlefield, and Mantua. Hence, the water is free from industrial wastes and supports a profuse growth of microscopic organisms, which is ideal for fish life, though at times very annoying to the treatment plant management. Last year an unusual growth of *Anabaena*, extending from the middle of August to the middle of October, was experienced. At one time, the water entering the plant contained 42,800 standard units of algae, 37,500 standard units being *Anabaena*. Algae troubles are usually successfully combated at the treatment plant without resorting to copper sulfating the water in the reservoir. Copper sulfating Lake Rockwell is like trying to treat a river because of the operation of the hydro-electric plant and the frequent runoffs, even during the late summer period. Due to the dry season and the difficulty of treating the water containing such large quantities of algae, however, the treatment had to be resorted to.

Fishing in Lake Rockwell, except along the public highway, Route 14, which is not under control, is prohibited. Each year, however, the State Conservation Commission removes fish from the lake and plants them in the various open waters of Summit and Portage Counties.

The 1,400 acres about Lake Rockwell are devoted to farming, afforestation, and fruit growing. This area is fenced, and cultivation and fertilization are done with great care to prevent contamination of the waters of the lake. The 10,000 fruit trees, together with the vineyards, occupy about 150 acres, while 500,000 pines have been planted on 400 acres. A nursery is maintained for growing pine seedlings for transplanting to the various properties of the bureau.

3. New Impounding Reservoirs

During the past year, two new impounding reservoirs have been placed in service.

In general, all engineering work involved in the design and supervision of construction for plant expansion and maintenance is done by the bureau's own engineering force. The engineering involved in these two reservoirs was carried on in this manner except that the reservoirs were designed by F. A. Barbour of Boston, who also acted as consultant during construction.

East Branch Reservoir: The East Branch Reservoir, located northeast of Burton in Geauga County, is an addition to the present domestic supply. It was constructed in 1938 and 1939 by the Bates and Rogers Construction Corporation of Chicago, under a P.W.A. grant.

An earth dam, 2,400 ft. in length, with a concrete "around-the-end" spillway at an elevation of 1,132 ft. above sea-level forms a reservoir of 420 acres with available storage of 1,500,000,000 gal. of water. The gates were closed early in the fall of 1939 and the water reached spillway level on March 9, 1940.

The marginal lands about the East Branch will be planted with pine.

Mogadore Reservoir: As a result of the continued deficiency in rainfall throughout northeastern Ohio from 1930 to 1934, the groundwater table had, in 1934, dropped to such an extent that private supplies developed by Akron industries were seriously affected. At that time, preliminary studies were started, investigating possible sources of untreated water to reinforce private supplies, especially those of the East Akron industries which had suffered the most. As an emergency matter, treated water was discharged into the Little Cuyahoga River at Massillon Road to provide immediate relief.

Following the preliminary study, extensive topographical and property surveys were made of the Mogadore Reservoir basin of

the Little Cuyahoga River in Portage County east of Mogadore. The development of the Little Cuyahoga River as a source of water supply had been under consideration for a long time. In fact, in 1911, it was one of the sources considered as the sole supply for the City of Akron.

The reservoir—a W.P.A. project—was started in 1936, and brought to practical completion in 1938. It includes an earth dam at an elevation of 1,087 ft., and 700 ft. long, with a concrete "around-the-end" spillway, two earth dikes, totalling 3,500 ft., at the upper ends of the reservoir to prevent shallow flowage, the raising and regrading of 4,150 ft. of Route 43, and the relocation of gasoline and oil transmission lines.

The reservoir, thus created, has a water surface of 900 acres and will store approximately 2,250,000,000 gal. of water.

In addition to making available a controlled flow of 5 to 8 m.g.d. of untreated water for use by the East Akron Industries, a notched weir, 3 ft. high, will retain a maximum of 1,000,000,000 gal. of water during flood periods, allowing the water to pass down after the flood has passed.

Due to legal difficulties in connection with the vacating of certain roads in the Mogadore Reservoir area, the actual storage of water in the reservoir was delayed until the beginning of 1940. The late snows and the spring rains, however, filled the reservoir to about 80 per cent of its capacity by May.

The East Branch Dam and the embankments of the Mogadore Reservoir were constructed of earth by the rolled-fill method.

The designs of the embankments are quite similar, varying only in their external slopes, an impervious core flanked on either side by a pervious section. The downstream slopes of the embankments were either seeded or sodded and the upstream slopes were paved with concrete block cast in place.

With the addition of these two reservoirs, it is felt that the water supply of Akron is insured for some years to come.

The 1,130 acres of marginal land at the Mogadore Reservoir will be devoted to recreational use. Bridle paths and park roads leading to play and picnic areas have been constructed. A large part of the side hill was planted with pines and hardwoods.

The waters of both the East Branch Reservoir and the Mogadore Reservoir are closed to fishing. It is possible that after these waters have been seeded that restricted fishing may be allowed.

4. Use of Surplus Land

In anticipation of the construction of additional reservoirs on the Cuyahoga River watershed, and to preserve the City of Akron's rights and purposes in the upper valley of the Cuyahoga River, the city, since 1920, has acquired in excess of 8,100 acres of future reservoir land along the river in Geauga County.

Some 1,350 acres of this total is represented by what is known as the East Branch Reservoir and its surrounding lands. The balance of the lands scattered throughout the basin of the proposed larger Troy reservoir is at present devoted to general farming, grazing and dairy purposes, under direct operation by the city, or by lease. In 1930, at the beginning of the depression, the clearing of some 1,800 acres of lowlands, eventually to be flooded by a future reservoir, was undertaken by the city at its own expense. This project used relief labor and about $150,000 was expended in clearing operations. To preserve the investment, a policy was adopted whereby the city acquired sheep and cattle strictly for grazing purposes. At the present time the city maintains a herd of from 400 to 500 Hereford cattle and a flock of 650 to 800 DeLaine sheep. The cattle are strictly range cattle, the increase being sold each year to keep the herd at a predetermined level. All grain, hay and ensilage used for feeding purposes is raised by a force of farmers paid by the city and living on city properties. In other words, the herd and flock are self-sustaining, and since its inauguration in 1931, the policy has proved a self-sustaining operation. It must be remembered, however, that the prime purpose is the protection of cleared areas and the prevention of the regrowth of young trees and brush, which in ten to fifteen years would, otherwise, present another clearing problem.

5. Raw Water—Its Delivery and Treatment

Water from Lake Rockwell flows by gravity through one-half mile of 48-inch cast-iron pipe to the treatment plant. A new lake intake and about 900 ft. of 72-inch concrete pipe have been constructed and connected to the 48-inch conduit. The new conduit will be extended to the plant as rapidly as the demand for water requires.

The treatment plant consists of a head house and filter building as an integral unit. The first floor of the head house is used for office, laboratory, chlorinating and iron sulfate equipment, standby

alum machine and gasoline-driven low-lift pump. The second floor houses alum, lime and carbon dry feeders, carbon storage and pumping station condensate-recovery plant. The third floor is used for alum and lime storage. The basement of the head house is used for wash water pumping units, while in the substructure directly below the first floor is the clear water suction well.

Water from the reservoir passes through the head house three times during the process of purification. This compact arrangement allows for raw, applied and filtered water treatment within a relatively small space. Mixing chambers are of "around-the-end" type, with a mix of about three minutes. Coagulation basins are six in number, of 4½ mil. gal. capacity, with about four to five hours' retention at normal rates.

The 25 filters, of 2 m.g.d. capacity each when rated at 125 m.g.d. per acre, are equipped with "Wheeler" bottoms.

Clear wells of 1.6 mil. gal. capacity are located beneath the filters.

The outstanding feature of the plant is the use of waste acid pickling liquor from a nearby steel mill as the coagulant. The pickling liquor is delivered to the plant in a tank truck and stored in a large wooden tank. From the storage tank, the liquor flows by gravity to a rubber-covered orifice box. A hard rubber water ejector lifts the liquor from the catch basin of the orifice box and ejects it into the chlorinator discharge hose in which oxidation of the ferrous sulfate occurs. The resulting mixture, called "chlorinated copperas," is then fed to the raw water. As much as 50 lb. per mil. gal. of chlorine has been used for iron oxidizing purposes, the maximum day's use being slightly over 1,200 lb. The use of chlorinated copperas has effected a saving in operation cost of about $0.72 per grain per mil. gal. at current alum prices

6. Pumping of Treated Water

From suction wells in the substructure of the treatment plant, water is pumped to Akron against an average lift of 190 ft. by two "Tod" triple-expansion pumping engines, and three centrifugal pumping units, having a total nominal capacity of 58 m.g.d., provided in units ranging in size from 5 to 15 m.g.d. in capacity. This large capacity insures reserve for supplying peak demands and to allow units to be out of service for inspection and servicing.

Electric power is generated at the plant. In times of heavy stream flow, water otherwise wasted over the dam, is partly diverted through

100- and 300-h.p. water turbines. Power thus generated is used for lighting and miscellaneous purposes at the pumping station and treatment plant. When sufficient power is available, a 5-m.g.d. electric-driven centrifugal pump is placed in service, pumping water to Akron. In 1939, 7 per cent of all the water delivered to Akron was pumped by this surplus power. When the water turbines are not in operation, power is supplied by two 75-k.v.a. steam-turbine-driven generators in the pumping station.

On rare occasions very low water in Lake Rockwell necessitates the use of low-lift pumps to boost the water into the treatment plant. Gasoline- and steam-turbine-driven pumps of a total nominal capacity of 57 m.g.d. are provided for this purpose.

Steam for all purposes at both the treatment plant and pumping station is furnished by four 300-h.p. "Stirling" boilers with "Riley" underfeed stokers, an economizer, heating the feed water to 250° F., and forced and induced draft fans.

The condensate from the triple-expansion pumps is pumped to the treatment plant where the oil is removed and the water returned to the feed-water system.

Outside storage is provided for 7,000 tons, or approximately one year's supply, of coal, received in carload lots. A locomotive crane loads the coal into suspended steel bunkers in front of the boilers. Ashes removed by a vacuum ash conveyor and discharged into an outdoor brick ash hopper of 1,700 cu.ft. capacity are used in road improvement about the plant and at Lake Rockwell.

7. Delivery of Treated Water and Reconditioning of Force Mains

The water from the Cuyahoga River Pumping Station is delivered to Akron through 11 mi. of parallel 36-inch and 48-inch force mains, cross-connected each mile.

The original installation was a single 36-inch lock-bar pipe main. In 1919–22, the 48-inch main was laid to take care of the increased demand for water. Some corrosion had been observed on a portion of the 36-inch main, and, following an electrolysis survey and adjustment of power lines, 48-inch lock-bar steel pipe was installed with the exception of about a mile in the vicinity of Tallmadge Circle, where cast-iron pipe was used.

For the past five years, repairs have averaged over 40 per year, with the majority occurring in a relatively small portion of the total length and area of the pipe. Each repair necessitates the shutting

down and draining of a portion of the main, with an increased head on pumps. For some time, the bureau has been watching the process for lining steel pipe in place as developed by the T. A. Gillespie Company. An application for a P.W.A. grant, to line a portion of the main, was rejected on the basis that it was "maintenance," although it was endeavored to show that it was a "betterment," in that it prolonged the life expectancy of an existing structure and also improved the structure by reducing friction, with consequent reduction in head on the pumps. Late last year the work was set up and approved as a W.P.A. project. The city then entered into a contract with the T. A. Gillespie Company for lining about 20,000 ft. of 36-inch main and 14,000 ft. of 48-inch main, the contractor to furnish supervision and equipment; the materials and labor being furnished by the city and by W.P.A. Work is now under way by the Centriline Company, a sub-contractor for the T. A. Gillespie Company.

Briefly the process of lining is as follows:

The pipe is rough-cleaned by a water-propelled machine developed by the National Water Main Cleaning Company. Hand cleaning by the W.P.A. labor removes all coating, rust, and other foreign matter not removed by the mechanical cleaner.

The mortar lining is a 1:1 mixture of portland cement and screened sand and is of such consistency as to provide a dense, homogeneous lining which will hold itself against the pipe surface. The water-cement ratio is carefully controlled and kept to absolute minimum.

The lining, $\frac{1}{4}$ in. to $\frac{1}{2}$ in. thick, is placed by a rapidly revolving head which throws the mortar against the pipe. A series of paddles attached to this machine smooths the lining, leaving a dense, hard surface. The speed at which the machine travels along the pipe determines the thickness of the lining. For $\frac{1}{4}$-inch lining, the speed is about 3 ft. per min.

A portable generating plant furnishes power for operating the lining machine, for lighting and for charging the storage battery cars used to convey the mortar from the outside mixer to the lining machine.

8. Repumpage to High Service Districts

Akron is a city of hills and valleys, with elevations ranging from 800 to 1,200 ft. The over-flow of the main equalizing reservoir on Goodyear Heights is at an elevation of 1,198 ft.; consequently there is considerable area within the city that cannot be served by gravity

or "normal service" but must be served by repumpage to "high service," or, rather, "high elevation" districts.

At present, about one-eighth of the water delivered to Akron is so repumped into five districts. It is probable that one or two additional districts will be required in the future.

Each station is visited daily by the junior electrical engineer and a monthly inspection is made by the electrical engineer from the Cuyahoga River Pumping Station.

The pumping stations serving these districts are equipped with full automatic electric controllers operating 3-phase, 60-cycle, 220-volt induction type motors rated 1,750 r.p.m. full load, and direct connected to pumps. Each of the five high service stations is equipped with at least two centrifugal pumps so arranged that, should one of the units fail to operate due to mechanical fault or failure of any part, the other pump can be placed in service without delay.

The circuit on the starting equipment is opened and closed by means of control wires from an electric contactor at the tank or standpipe. Control must arise at these sources since friction condition between tank and pumps depends upon rates of consumption in the district between the pump and standpipe or tank.

A signal system is in operation at three of the most important pumping stations, whereby the Johnston Street Yard can be notified as to the failure of a unit in operation due to overload caused by mechanical trouble or by the opening of a main circuit breaker from the power supply by electrical disturbances caused by lighting. The bell alarm signals are operated through battery voltage contactors mounted on the overload relays which close the signal system when the relay trips.

In one district, a normally open contactor, mounted inside a pressure gage, closes the bell-alarm circuit when the water in the tank falls to a pre-determined level.

Several of the districts have ample storage capacity to permit the operation of the pumping station as a one-pump station. In those stations, double-throw switches have been installed so that either pump (but not both) may be operated at any time. This provides the necessary reserve pump, and at the same time reduces the "connected load" with an appreciable reduction in power costs.

At the West High station (a three-pump station), a new 60-h.p. totally enclosed controller, modern in design, and equipped with overload and low voltage protection, together with a time delay

device from starting to running has recently been installed. The new installation is in line with further changes to be made in this particular station, where, by adding two double-throw, 3-pole, switches, selection of any combination of the three pumps with the use of only two controllers will be possible. This change-over, when completed, will cut down the stand-by charge, as only two of the three pumps can operate at one time, and will mean an appreciable saving in power cost.

9. Storage of Treated Water

The Cuyahoga River Pumping Station, with the largest unit out of service, has a nominal capacity of 43 m.g.d. To equalize peak demands and to provide reserve for fire protection and emergency demands, storage of 30 mil.gal. is provided within the city limits. As the present average demand is about 22.5 m.g.d., the pumping station has a safe capacity of 190 per cent of the average daily demand, and the water stored within the city limits represents 130 per cent of that quantity. This, supplemented by the 2-m.g.d. emergency supply from the Kenmore well fields, is believed to be ample for some time to come.

The original plant provided for storage of 20 mil.gal. By creation of high service districts and the acquisition of existing plants this was increased to 23 mil.gal. by 1932.

The hot dry summer of 1930 indicated the inability of the distribution system to deliver water under adequate pressure to outlying districts during periods of high demand. A study of the situation resulted in the adoption of the policy of erection of standpipes on the outlying portions of the distribution system, where they will afford a secondary source of supply during periods of high demand.

The use of standpipes, instead of the usual elevated tanks, was based on the idea that the additional stored water in the lower part of the standpipe—which is not needed under ordinary operation—is a valuable reserve for emergency uses.

In 1932, a 1.5-mil.gal. standpipe was added to the West High Service District, this being the weakest link in the system. In 1937, three P.W.A. projects, involving about 6,000 ft. of 12-inch and 16-inch connecting mains and three standpipes (two of 2-mil.gal. capacity and one of 1.5-mil.gal. capacity) were approved. The 1.5-mil.gal. standpipe is part of the South High Service District, while the two 2-mil.gal. standpipes are on the normal system. These

standpipes are of the welded type with bituminous interior coating. Erection of all standpipes was completed in 1938, and they were placed in service early in 1939.

The erection of the standpipes was awarded to three different manufacturers with consequently three different methods of erection. In this work, the various methods of making the welds made less difference than the methods used to place and hold the plates in position before welding. The exterior painting was a simple matter, but the interior required a job that would fully hold and protect the metal during hot weather and not check during very cold weather. The interior painting is guaranteed for seven years. The general contractor put on a priming coat covering all seams before turning it over to the sub-contractor. The sub-contractor then used one coat, applied cold, and one coat of a specially compounded covering, applied hot. The latter was made principally of coal tar and was applied to a thickness of $\frac{1}{16}$ in. or more.

10. The Distribution of Water

The distribution system of the Akron water supply consists of some 645 mi. of pipe varying in size from 4-inch to 48-inch, furnishing water to about 88 per cent of Akron's area of 54 sq.mi. and the neighboring Village of Mogadore, with a pressure varying from 30 to 145 lb.

Under W.P.A. programs, several miles of pipe have been laid each year for the past several years. Practically all new mains are laid with lead-substitute joints, using packing known commercially as "Flexo-Pac." "Flexo-Pac" is made in Akron, and is found to be very satisfactory as a substitute for hemp or jute.

Several 30-inch and 36-inch feeder mains lead from the force mains and equalizing reservoir into the city. The system of using encased gears on horizontal valves has been adopted, and in numerous cases has replaced the old open gears in the manholes, thus reducing maintenance expense. Cone valves were used on the new 24-inch feeder main.

In the past two or three years the bureau has, under P.W.A. projects, increased the efficiency of the system by construction of 30-inch and 24-inch distributing lines to give more water to the south section of the city. The southwest section has been greatly benefited by the installation of a 20-inch line on the South High Street grade elimination.

Under government projects, where mains, services or hydrants have to be adjusted for the construction of highways, sewers, or bridges, all common labor is furnished by W.P.A., but the skilled labor for actual changes is furnished by the water department. Other departments for whom these changes are made are subsequently billed by the water department.

The system of valve location is rather unique. Each repair or emergency truck is furnished with a complete set of blue prints, in book form, showing location, size and kind of valve in use.

There are about 5,430 fire hydrants, in Akron, bought, installed and maintained by the water department and, with the cooperation of the Superintendent of Hydrants of the Fire Department, these hydrants are kept in excellent condition. Nearly all have valves on the branches, the exception being in the annexed Kenmore District, but the condition there is gradually being eliminated.

January and February seem to be open season on breaking of hydrants, and yet fewer hydrants are broken on ice covered streets than elsewhere. When the weather moderates, the drivers of cars seem to become careless, and it is then that there is a concentrated attack on hydrants. In the placement of hydrants, Akron had adopted a standard, in residential districts, of setting them on the extension of the lot line between two properties.

As with any growing system, Akron has a number of "dead ends" in its system and also mains where consumption of water is very low. This, at times, necessitates considerable flushing to forestall complaints of "bad" water. No flushing or use of hydrants, however, is allowed in residential districts on Monday, thus eliminating most complaints of colored or rusty water on the normal wash day.

Holiday and night emergency service is maintained through the switchboard operator, at the Johnston Street office, who has instructions for contacting the proper men in case of breaks, low pressure in the "high elevation" districts, and other emergencies.

Little trouble in the thawing of frozen services with electricity has been experienced, but now—with the use of copper services and of a non-metallic pipe joint—the problem has increased, for there is no longer assurance of a closed electric circuit between house and house, or house and fire hydrant. After the service is thawed, the consumer is instructed to let the water flow in a stream about the size of a lead pencil, but no adjustment is made in the bill for the

water so wasted. Should the service freeze a second time, the charge for thawing is the same as for the first time. When it is necessary to connect to the piping in the basement, the meter in the house is disconnected or removed to prevent short circuit with its resulting fires or explosions.

It is very essential that all mains and services be placed at a depth which will eliminate freezing and, that a critical public may be supplied with satisfactory water at all seasons of the year.

11. City Properties

The activities of the city end of the water supply system are centered in the yard on Johnston Street. This is a typical water works maintenance building with meter testing and repair shop, storeroom and garage, and outside storage for pipe and fittings. The storeyard has been empty of pipe due to the fact that recent pipe contracts provide for delivery on the street and stored pipe represents only that needed for maintenance work.

A portion of the property is devoted to the highway and sewer departments, over which the water department has no control.

The storeroom—handling all small items—is a $40,000 business. A perpetual card inventory is kept and a physical inventory is made annually. Recently there has been instituted a system whereby every truck is inventoried quarterly. This prevents trucks from becoming secondary storerooms, and also assures that all tools are in good condition.

The garage and repair shop service 54 equipment units of the Bureau of Water Supply, and 13 units for other city departments. The repair shop does all repair work for the bureau.

The numerous reservoirs, standpipes, and elevated tank sites, repumpage stations, and the Kenmore supplementary pumping station require considerable maintenance, especially during the summer months when the mowing of grass is no small item. Under a W.P.A. project, an extensive landscaping program of the various sites is in progress. The stations and tanks are painted periodically. The steel tanks and standpipes have to be taken out of service for re-coating, thus necessitating direct pumping during the period. As an experiment, a "Rusta-Restor" outfit has been installed on one of the tanks, and it is expected to effect considerable saving in maintenance expense.

12. Service Permits and Meter Billing

Akron looks only to the property owner for water rent; and service permits are taken out in his name.

In general, domestic services are $\frac{3}{4}$ in. in diameter. Where a larger demand for water is indicated, a $1\frac{1}{4}$-inch service with a 1-inch corporation cock is used. Domestic services being paid for by the consumer, the smaller services are usually requested. Because there is only a $5 differential in price, however, the bureau has, in many cases, been successful in urging consumers to have $1\frac{1}{4}$-inch services installed wherever they seem feasible.

The bureau does not use $1\frac{1}{2}$-inch or 2-inch taps, and if more water than can be supplied by a 1-inch corporation cock is demanded, a 4-inch connection must be installed. Experience with 2-inch and 3-inch gate valves indicated that the stems of the valves were too weak for ordinary operation, consequently their use was abandoned several years ago.

The city installs services to the property line where the owner picks it up and extends it to the building. When permanent pavement is laid, services are installed to the property line. When the paving is assessed and services are installed by the city, the bureau is reimbursed from the assessment fund. The old services, installed by the water company, and the non-assessed city services, are carried by the city until picked up by the owner of the property—in which case he pays the original cost if a company service, and the standard service price if a city service. There are now about 9,000 services, which have not been picked up, installed on paved streets.

The 56,000 domestic meters are divided into three districts for quarterly billing. Industrial meters, $1\frac{1}{2}$-inch and larger, are billed separately under a fourth district. All bills for a district are mailed on the first of the month. The postcard and bound ledger system is used, the readings and billings also being entered on a card which serves as a record card for that service and is available for use in conferences with customers regarding bills. The reading cards are received by the billing clerk, arranged in numerical order. After billing and checking, the cards are returned to the meter department for sorting back into routes. This sorting is necessary, as account numbers are not grouped geographically, but are based on the chronological order in which the services were installed. Two clerks bill 1,800 accounts daily; postcards are addressographed by a third clerk, who also sorts the readers' cards.

13. Domestic Services and Meters

The water is delivered to the consumers through approximately 56,000 domestic meters. The bureau has adopted the term "domestic meters" for all 1-inch and smaller meters, reserving the term "industrial meters" for those $1\frac{1}{2}$-inch and larger, which are read, tested, and repaired by a separate organization.

The importance of the service and meter group in handling its affairs efficiently is of no small consequence in building good will for the bureau. The truth of this statement can be realized when it is considered that the men of the service and meter group are the only employees of the bureau, outside of the tellers, with whom a large proportion of the citizens come in contact.

Numerous special tools, such as the sand blasting chamber for cleaning meter cases, gear puller tools for cleaning discs and chambers, standardized service fittings, and special fittings, have been developed for the use of this department.

14. Services

At present most domestic services are $\frac{3}{4}$-inch copper tubing. Old services range from $\frac{3}{8}$-inch corporation cocks with $\frac{3}{8}$-inch galvanized pipe to $\frac{1}{2}$-inch corporation cocks with $\frac{3}{4}$-inch lead pipe.

Installation of services under pavement and walks is facilitated by an earth auger welded to a section of pipe of smaller diameter than the auger, thus permitting the easy removal of dirt. This has been successful for borings up to 20 ft. The use of dry-ice for repairing small services while under pressure has been found practical and economical. Only one excavation is required, that at the leak, and as a result there is a considerable saving in cost, especially when repaving is required. If dry-ice is not used, an excavation is required at the main to turn off the corporation cock, or the main must be shut off, causing inconvenience to consumers in the neighborhood.

After the bureau had adopted the policy of turning off services for non-payment of water rent, it was discovered that often the service had been turned on by the consumer or his friends. It is possible for a person, without a shut-off key, to lift off the cover and turn on the service by using an improvised wrench.

To eliminate this practice, a scheme of blocking the service box

was adopted. The top of the operating rod of the curb stop is 10 to 12 in. below the cover. A cast iron ball fits snugly into the curb box above the rod and as the working space is limited, it is difficult to remove the ball with ordinary means. The bureau man carries a magnetic coil which he attaches to the dashboard of his car or to a 3-cell dry battery, lifts out the ball, and operates the stop. Iron chips over the iron ball prevents the use of a tube to lift it.

Meter reading occupies the time of ten or eleven meter men during the first fifteen to eighteen days of each month. A "route" of meter cards, containing cards of 175 active and inactive meters,constitutes a day's work. Readers thus have all cards and can check as to whether water is being used through services believed to be inactive.

About 3,000 curb meters are installed where the house is over 60 ft. in back of the property line, where there is extensive lawn irrigation, or where meters are likely to be frozen in the cellar. The city assumes responsibility for frozen meters in curb settings; therefore, during winter months the pits are not opened, the bill for the quarter being estimated. When concrete is placed against the cover, freezing of the meter may be expected in extremely cold weather.

After the meter men complete their meter reading for the month, they come into the shop and do miscellaneous meter work, assisting the two full-time shopmen.

All one-inch and smaller meters are furnished and maintained by the city and are removed, cleaned, and tested after they have registered 100,000 cu.ft.

Meters are tested to 120 lb. static pressure to detect leaky joints or defective frost bottoms. For accuracy they are tested on $\frac{3}{8}$-inch and $\frac{3}{64}$-inch streams under 40 lb. pressure at the inlet of the first meter of the series of not more than seven meters of the same make. Since about 65 per cent of the consumers use less than the amount allowed by the minimum bill (2,000 cu.ft. per quarter), it is believed that extensive tests of domestic meters are not economically justifiable. When installed, all meters are geared to register 98 per cent on the $\frac{3}{8}$-inch flow.

Repaired meters are installed only on services using less water than the amount allowed by the minimum bill.

If a meter is damaged by misuse or negligence, the cost of repairing is charged to the consumer.

15. Industrial Services and Meters and Elimination of Cross-Connections

Over twenty years ago the importance of industrial services was recognized, when the installation, reading, repairing, and billing of the accounts was placed under a separate sub-organization by the bureau. Industrial services, as classified by the bureau, include some 500 metered services with $1\frac{1}{2}$-inch and larger meters and unmetered fire lines.

This organization also supervises the various pressure gages, installed in fire stations and schools for use of the engineering department in their study of the distribution system, domestic meter accounts requiring special attention, and the elimination of cross-connections.

To give an idea of the importance of industrial services the following percentages may be of interest. Less than 1 per cent of the total services in the system are industrial services. They consume 31 per cent of the total water pumped into the system, and 25 per cent of the total revenue from sale of water is derived from them. Each service has its own peculiarity and the schedule of meter readings provides that all meters be read according to the average daily consumption. Some are read daily, the others weekly, monthly, and, if the consumption is less than the minimum rate for the size of the meter, quarterly. This provides a close check on the operation of the meter, insures prompt repairs and provides data for making an intelligent estimate of water consumption when the meter is not registering.

Every meter is completely overhauled within a period of two to three years. This reduces the maintenance costs which are charged back to the consumer when parts are used in the repair.

When the State Department of Health ordered that cross-connections between the city supply and other sources of water be broken, the work for the bureau was handled by the industrial service organization. Piping surveys were made, sketches with suggested changes were drawn and submitted to the state department, consumers were contacted, and recommendations were made for the elimination of the connections. Due principally to operating conditions which had to be changed in the plants, the expense involved, and the former rulings, the work has been slow, but with the fine cooperation of the state department and the consumers it can now be reported that

practically all cross-connections have been eliminated. Periodic inspections are made to assure that broken cross-connections remain broken and that new ones are not made.

The men in the department are trained to handle any phase of the work of the entire bureau. With excellent equipment and with men who take an interest in their work, the work has been carried on with a high degree of efficiency.

Testing of meters in place is done when bypass lines and test valves are provided. This insures accuracy of the meters and supports the rendering of invoices in excess of normal use. By convincing the consumer of the value in having a bypass line and test valve on the meter setting, success has been had in changing some of the older meter settings that did not have this feature.

The inability to shop-test meters under large flows is a handicap. It is expected, however, that this will be corrected in the near future. Studies are being made looking toward the installation of a large meter testing outfit at the Johnston Street Yard.

A careful study of the use of water by each consumer is made to determine the proper size of meter required. As may be expected, changing industrial conditions have resulted in some services being over-metered. This is difficult to correct since in Akron, meters 1½-in. and larger are owned by the consumers. This question, also, is being studied by the bureau.

16. Collections

Water bills, due and payable on the first of the month, are subject to a discount of 20 cents per 1,000 cu.ft. on the first 20,000 cu.ft. and 10 cents per 1,000 cu.ft. for all over this amount, if paid on or before the twentieth of the month. This practice was put into effect late in 1935, and has played an important part in reducing the number of delinquent accounts.

Previous to 1930, accounts receivable averaged $45,000, but during the early years of the depression they rose rapidly, reaching a maximum of nearly $300,000 by the end of 1933. These have now been reduced to about $60,000. There are several different factors which contributed to this reduction: first, the adoption of the discount system previously mentioned; second, use of outside collectors who endeavored to call on all consumers owing water rent for more than one quarter; and third, an unfavorable court decision. Before this decision became effective, water bills were a prior lien against the

property, the same as unpaid taxes, which had to be satisfied before the sale could be completed. Under the present system, when the purchaser calls to sign a water contract and refuses to pay any delinquent bills, he signs an abatement sheet. The balance is then removed, but charged on a separate account to the former contracting party; and should he ever request to sign a water contract, service is refused him until the old bill is paid. But in order to reduce the number of new abatements, foreclosures filed are being followed and it is insisted that the account be paid in full before the date of sheriff's sale, and kept paid up until the new owner signs a water contract. In some cases, collection is even made in advance after the sheriff's sale, until the new owner has signed the contract.

The fourth and last factor will be elaborated somewhat since it has been found that the elimination of collectors and the present shut-off system are most effective. After the discount date on any particular month, a bill unpaid becomes delinquent and on the first of the following month "first notice," which states merely that the bill is delinquent, and that service may be turned off, is mailed out. This brings in returns from 60 to 70 per cent of the accounts. One month later "final notice" is sent. This informs the consumer that unless a payment is made within one week, the water will be turned off. When the due date arrives, turn-off orders are made on all accounts which have not been paid, and are given to the turn-off men. Partial payments to the turn-off man are not permitted unless approved by the office. It is not the bureau's intention to handle collections in this manner, and the bureau has tried to discourage the practice. In the office duplicates of the delinquent bills are prepared. These bills carry the date of mailing of first and final notices as well as the date of the turn-off order. By these notations it is known just what has transpired when the consumer calls at the office; and it also permits checking on turn-off orders so that the water will not be turned off after a payment is made.

When bills are long overdue and it is impossible to shut off the water due to humanitarian considerations, a brass disc with a $\frac{1}{32}$-inch hole is installed in the service line. This allows water for sanitary purposes but makes it very inconvenient to use water for other purposes. In numerous cases where the discs were installed, the consumer immediately came to the office and paid the full amount of the back bill.

17. Accounting

It is an accepted fact that some system of cost accounting for a water works system is necessary as a control of efficiency and as a basis for charges to consumers. It is, therefore, the function of the accounting division to assemble these costs.

The bureau's finances are handled in two funds: the Bond Fund and the Operating Fund. The moneys in these funds are deposited daily with the City Finance Director and banked with general city funds.

All checks for payments of vendor's invoices, contracts, payrolls, etc., are drawn by the City Finance Director.

An account with the water funds on the cash basis is kept in the Finance Department office, but not in sufficient detail for the purposes of the bureau. Therefore, the Bureau of Water Supply keeps a complete set of records.

The Appropriation Journal is segregated into: (1) five main divisions of operation and maintenance—supply, filtration, pumping, distribution, and commercial; and (2) capital expenditures from operating funds and debt service, with rotary accounts for stores, garage operation and blue printing.

The Bond Fund Journal is divided into the various items of plant structures.

At the end of each month a statement is drawn from the bureau's books representing the cash expenditures for the period. All unpaid bills are then listed on a distribution sheet and added to the cash expenditures in their respective accounts, the result being the actual expenditures for the period.

By the use of a skeleton ledger, consisting of asset, liability, proprietorship, and income accounts, a balance sheet and income statement can be prepared at the close of each year.

The billing of water rents is handled by the meter billing and collection group.

The rotary accounts are reimbursed each month.

The bureau has some 175 employees, 120 of which are on a salary basis, and 55 on an hourly basis. Payments for both classes of employees are made semi-monthly. Practically all are members of the State Employees Retirement System, requiring deductions from their pay.

Charges for personal service are made as follows: The annual

budget sets up the code to which each salary position is to be charged throughout the year. The distribution of the charge for hourly men is made from the time slips to a set of distribution sheets. Time slips are posted also to the payroll sheets. This acts as a double check on payroll computations.

Cost records of automobile operations, blue printing, meter repairs, and the bookkeeping involved in billing for miscellaneous services is all a part of this accounting group.

18. Office Practice

The business office is entrusted with the billing, collections and related functions of water accounts. During each quarter, 56,000 accounts are billed and collected. The problems of all offices are similar and the methods employed vary slightly with the type of equipment, records, information desired and local conditions.

Business offices are, in most cases, one of the main points of contact between the consuming public and the utility. This challenges the organization to obtain and maintain the good will, confidence and commendation of the public. The basic principles involved in this field of public relations and practiced by this organization are: (1) accurate and up-to-date records of the consumer in dealings with the utility; (2) courteous and prompt handling of the customer; (3) a fair hearing, investigation, and disposal of all complaints and requests; and (4) impartial and consistent interpretation and enforcement of regulations.

Experience with the public indicates that unfavorable reaction is not experienced in refusing to grant favors or unjust requests, when uniformly and impartially refused. Requests for adjustment of large bills has become negligible due to the consistent interpretation of the regulations over a long period of years. The consumers are well aware that adjustments are not made on occasional large bills due to large consumption, and that adjustments are not made on bills that are high due to visible leaks. In fact, it is accepted that the consumption shown by the registration of the meter is the consumption which is billed and for which payment is made.

In 1935, a discount for prompt payment of water bills was put into operation. During its infancy, a liberal interpretation was placed upon the regulation while the education of the consumer was in progress. The knowledge is now general that bills not paid on or before the final discount date must be paid in the gross amount.

Excuses of "on vacation," "sickness," "did not receive the bill," "just a little favor—I won't tell," "I supported the Administration," and many others are diplomatically dismissed. Consumer reaction in most cases is passive, and the rejection accepted in good grace and forgotten. These refused persons form a potential source of dissatisfaction if a change in the policy or in effective administration would relax the vigilance on the discounts.

Absolute impartiality is used in the enforcement of collections, as can be attested by elective public officials, public employees, both city and county, prominent citizens, *et al.*, who have permitted their bills to reach the stage of "service discontinued for non-payment." The policy is to give every reasonable consideration to every person honestly cooperating in the liquidation of water bills. Others are given impartial treatment as an analysis of the account dictates.

In a public water utility—especially one not under the control of a commission—the cooperation of the mayor and cabinet in impartial administration of regulations must be obtained. Fortunately this cooperation is, and has been, with few exceptions, forthcoming from recent city administrations.

ABSTRACTS OF WATER WORKS LITERATURE

Key. 31: 481 (Mar. '39) indicates volume 31, page 481, issue dated March 1939. If the publication is paged by issues, **31:** 3: 481 (Mar. '39) indicates volume 31, number 3, page 481. Material enclosed in starred brackets, ★[ ]★, is comment or opinion of abstractor. Initials following an abstract indicate reproduction, by permission, from periodicals as follows: *B. H.—Bulletin of Hygiene (British); C. A.—Chemical Abstracts; P. H. E. A.—Public Health Engineering Abstracts; W. P. R.—Water Pollution Research (British); I. M.—Institute of Metals (British).*

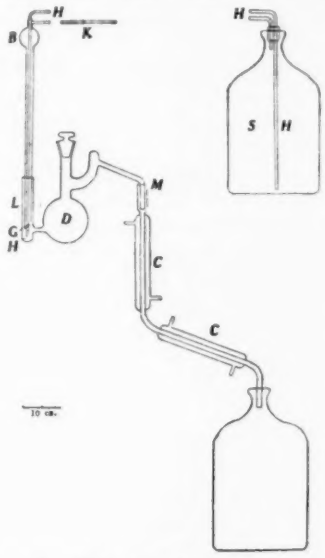
LABORATORY METHODS, EQUIPMENT AND APPARATUS

Water Inspection. HAROLD LOWE. J. Royal San. Inst. (Br.) **61:** 27 (July '40). Author gives proper methods of collecting water samples and discusses analytical methods used. Sample should be kept cold unless analysis can be begun immediately; should be accompanied with full details of source of sample and supply. Methods used similar to *Standard Methods.* Usual sanitary analysis includes: total solids in solution, chlorides, nitrates, free and saline NH_3, albuminoid NH_3, O absorbed from permanganate in 4 hr. at 80°C., tests for Pb, Cu, and Zn. Safe and desirable limits are: for Pb, 0.5 p.p.m., Zn, 5 p.p.m., Cu, not over 1 p.p.m., and Fe, not over 0.3 p.p.m. Bacteriological analysis includes: count on yeastrel agar at 37°C. in 24 hr., count on same agar in 3 days at 20°C. and enumeration of coliforms producing acid and gas in MacConkey's lactose and producing indole in peptone soln.; putting on in MacConkey one 50-ml. tube, five 10-ml. tubes, with 1-ml. and 0.1-ml. tubes with unknown and impure waters. Waters classified as highly satisfactory when less than 1 presumptive coliform organism present in 100 ml.; satisfactory with 1 or 2; suspicious, 3 to 10; unsatisfactory, greater than 10.—*Martin E. Flentje.*

Technique of Testing the Water of Chlorinated Indoor Swimming Baths. H. ANTON. Zent. f. Bakt. (Ger.) **144:** 294 ('39). So great is irregularity of mixture of inflowing chlorinated water and polluted tank water that no single sample can be representative. In colorimetric tests at temporarily closed public swimming bath, made after dye had been allowed to flow in for 3 hr., ratio of extreme high and low reading of 22 samples was greater than 20:1. Movements of swimmers would reduce but not remove such inequality of distribution. Average samples, though useful in comparing functioning of different installations, are of little public health significance; an opinion must always be based on worst sample. Water should be drawn at at least 3 points (1/6, 3/6 and 5/6) along each long side of bath, and at each point both superficially and deep—making 12 samples. Tests on water leaving tank to be

chlorinated are superfluous but, though it affords no index of tank-conditions, water returning to the bath after chlorination must be examined—making a minimum of 13 samples. Examination should be made late in day when bath is in full service and samples should be immediately de-chlorinated by adding 0.5 ml. N-100 $No_2S_2O_3$ to 150 ml. (or in case of silver-treated water Na. sulfide). *Coli* titre (100, 10 and 1 ml.) should in each case be determined and 0.1 ml. quantities should be plated on agar and Kebo plates and counts made after 8 days at 22°C. To ascertain that chlorination process is under proper control, free chlorine, at each point of sampling, should also be estimated.—*B. H.*

Constant-Level Still for Redistillation of Water. D. A. WILSON AND H. S. STRICKLER. Ind. Eng. Chem.—Anal. Ed. **11:** 636 (Nov. '39). Figure is drawn to scale, as indicated. Water is boiled in a modified 1-liter Claisen flask, *D*, with 2 or 3 beads to prevent bumping, and is condensed in double condenser, *C* and *C*. When level of water in *D* drops below any point predetermined by height to which *G* is set, air passes up through water in outer column to safety bulb, *B*, and thence through capillary, *K*, to reservoir bottle, *S*. This starts flow of water through siphon tube, *H*. Flow continues until end of *G* is again covered with water and water in *G* is in hydrostatic equilibrium with that in reservoir *S*. Purpose of capillary *K* is to introduce an appreciable lag in flow of water into flask *D*, so in no case does water cease boiling. Condenser bore must not be appreciably smaller than outlet, *M*. Thus, with coil-type condenser, constant-level device did not function. Although any condenser meeting above requirement may be used, compact double condenser, *C* and *C*, is found to give adequate condensation. To keep out dust, it is well to cover *L* with pyrex glass wool. *M* may be closed entirely. Apparatus may be mounted by using rod frame against a lab. shelf on which *S* sits, or by constructing wooden stand.—*Ed.*



A Simple Turbidimeter for Fairly Clear Water. A. A. HIRSCH. W. W. and Sew. **87:76** (Feb. '40). Glass tube, $4\frac{1}{2}' \times 1\frac{3}{4}''$, equipped with black rubber stopper target, in which scratches are made and in which drain is installed and filled with water. Drain is opened and water allowed to drop until scratch becomes visible. Device calibrated with standard turbidity suspensions. Range, 1.5-80 p.p.m. Readings below 1.5 are made possible by controlled soiling of sample with standard turbifacient. Black stopper used to reduce target contrast.—*H. E. Hudson, Jr.*

A Rapid Method of Checking the Accuracy of Reported Water Analyses. V. P. Sokoloff. Soil Sci. **49:** 57 ('40). Ratio of sum of cations or anions in water to sp. elec. conductance at 25° ordinarily falls between 0.085 and 0.122. Variations between these limits are affected by: (1) ratio of Na to total cations, (2) ratio of chloride to total anions, and (3) total concn. of electrolytes. After conductance of a water and its Na and chloride content are detd., total electrolyte content of water and sum of Ca plus Mg expressed as milliequiv. can be calcd. with considerable accuracy by means of factors presented. Method described is not a substitute for complete analysis but rather a means of detecting errors made either in course of such analyses or in calcg. and recording results. Where a rough est. of Ca plus Mg is all that is needed, method is satisfactory, provided important amts. of bases other than Ca, Mg and Na are absent.—*C. A.*

Automatic Device for the Extraction and Inoculation of Samples of Water for Bacteriological Examination. Raul Ferramola. Bol. Obras Sanitarias Nacion (Buenos Aires). **3:** 391 (Oct. '39). Describes apparatus developed at O. S. N. Microbiological Lab. for automatic inoculation of media, at any desired time interval, with measured amounts of water treatment plant effluent to obtain a better check on effectiveness of disinfection processes than is possible by the one-sample-a-day procedure. Apparatus is enclosed in wooden case divided into 2 compartments. One compartment houses clockwork which drives inoculating mechanism. Mechanism and culture tubes necessary for a one- or two-day run, are enclosed in other compartment. Two glass doors permit access to every part of apparatus and provide necessary protection to culture media while allowing, at all times, observation of instrument's performance. Inoculating device consists of a 10-ml. pipette sealed to a larger glass container which is provided with discharge tube at bottom to carry away any water which overflows from pipette. Device is attached to travelling frame which also carries tube for bringing continuous supply of water, to be examined, to pipette and a special funnel to catch and discharge into a waste gutter, the water coming out of the tip of the pipette between inoculations. In operation, media tubes are aligned under inoculating device in such manner that tip of pipette travels directly over them. As clockwork pulls inoculating device forward, series of cams, acting on a spring-operated plate, cause water inlet to pipette and drain funnel to be pulled aside simultaneously to allow 10 ml. of water to enter culture tube directly under pipette. At end of run, which for this instrument is 48 hr., inoculating at rate of one tube per hr., media tubes are taken from apparatus and placed in the 37°C. incubator for usual 24 and 48 hr. incubation. Carriage is pulled back to starting position and new rack with culture tubes put in place for following run. Results of some controlled experiments seem to indicate that neither exposure of media to air in inoculating compartment, nor fact that inoculated broth has to remain at room temp. for considerable time, before starting regular incubation period, have any appreciable effect upon reliability of bacteriological findings. —*J. M. Sanchis.*

A Sterile Transfer Chamber. ALDEN F. ROE. J. Bact. **39:** 589 (May '40). Permits inoculation and pouring of plates, examining and picking colonies, and other phases of open technique in a sterile atmosphere. All manipulations are plainly visible through glass window since illumination is afforded by two 100-watt lamps in upper front corners. Photograph and details of construction are given.—*Ralph E. Noble.*

Mobile Laboratories for Land and Water. ANON. Eng. News-Rec. **124:** 858 (June 20, '40). Labs. used in Ohio R. survey are described. Two trailer labs. are 206″ long, 78″ wide and 95″ high and are equipped with cabinets, refrigerator, sinks, 30-gal. water tank, gasoline stoves, autoclaves, incubators, hot air sterilizer, elec. hot plates, 6- and 110-v. wiring and tank and city pressure water systems. Trailer can be located in area under study, while tow car collects samples within 40-mi. radius. Cost of each complete unit, including tow car, equipment and 6 mo. supplies, was $3,671. Personnel of each consists of jr. chemist, lab. attendant and chauffeur. Floating lab. consists of boat 107′ long with 26′ beam. Upper deck is devoted to living quarters and lower deck to labs. Personnel includes an asst. san. engr., chemist, bacteriologist, 2 lab. assts. and 6 men assigned to sampling and boat operation. Auxiliary floating equipment includes 35′ motor-boat, yawl and fuel barge.—*R. E. Thompson.*

An Electronic Flow Meter. JOSEPH M. WEINBERGER. Electronics. **13:** 30 ('40). Automatic recording device for flow of water or other liquids through pipes. Vertical gage glass tube contains opaque liquid which, as it rises, intercepts beam of light focused on photoelectric cell connected through linear d.c. amplifier to recording voltmeter. Use of photoelectric cell provides practically frictionless and inertialess means of measurement with none of attendant losses inherent in mechanical apparatus. Threshold of operation is much lower than in any mechanical system. Construction details given. —*C. A.*

The Luximeter. W. L. CARSON. Gen. Elec. Rev. **43:** 91 ('40). Photoelectric instrument for measuring light transmission through a liquid consists of lamp maintained at constant light intensity, test-tube holder and light meter, all mounted in small case. Light from lamp passes through liquid to photoelectric cell which actuates sensitive indicating instrument. Rheostat in lamp circuit controls amount of light required for given test. Turbidity can be measured quite well over range 100 to 3,500 p.p.m. on silica scale.—*C. A.*

Coagulation Studies Using a Laboratory Stirrer. L. A. MARSHALL AND F. W. KLINGMAN. Ohio Conf. Water Purification, 19th Ann. Rept. 84 ('39). Purified alum containing 0.22% insoluble matter was compared with unpurified alums containing up to 7.43% insoluble matter. Results indicated that latter gave as good, but not better, coagulation in Lake Erie water as former, i.e., coagulating effect of insoluble matter is probably unimportant. It was observed that: (1) large fluffy floc was produced with gentle agitation and small

tougher floc with more violent agitation; (2) floc that has been formed and then broken up can be reproduced; (3) violent agitation for 30 sec. after introducing coagulant inhibited floc formation; (4) pre-formed floc can be used for partially clarifying untreated water; (5) coagulation is influenced by degree and period of agitation, which, within limits, appear to be functions of each other. Method of combining water and alum solution is of utmost importance in lab. expts. Alum solution should be introduced while water is being stirred or should be placed in empty beakers and water poured in quickly while stirring is in progress. Adding alum solution to quiescent water in beakers prior to stirring gives widely divergent results.—*R. E. Thompson.*

A Modified Apparatus for the Gutzeit Test for Arsenic. J. Wyllie. Can. Pub. Health J. **31:** 159 (Mar. '40). Apparatus consists of 50-ml. flask with 20-ml. side funnel and vertical delivery tube in 3 sections. First section contains fritted disc to remove acid spray and, above it, a little glass wool, impregnated with $Pb(OAc)_2$; second section filter paper impregnated with $Pb(OAc)_2$; and third is small condenser in which is placed $HgBr_2$ test paper. If procedure is standardized, AsH_3 is evolved at same rate and stains produced are comparative. HCl is used and temp. of apparatus, including condenser, is maintained at 20°C., which is optimum for AsH_3 production. Ferric alum is added to inhibit evolution of SbH_3, and $SnCl_2$ to reduce As compds. and render evolution of AsH_3 more uniform and complete. Directions are given for prepg. standard stains from standard As_2O_3 solns. Apparatus has been used for detg. 0.001–0.02 mg. As in water, hair and pulverized rock. Method of extracting As from rock prior to applying test is described.—*R. E. Thompson.*

The Measurement of the Thickness of Metal Walls from One Surface Only, by an Electrical Method. B. M. Thornton and W. M. Thornton. Proc. Inst. Mech. Eng. (Br.). **140:** 349 ('38). Method consists essentially of comparing resistance of surface with that of similarly shaped wall of same material and known thickness. Current, usually <10 amp., is supplied by a 6- or 12-v. battery to 2 current contacts held against surface. 2 further contacts made between those supplying current, and potential drop is measured. In practice most reliable method is to vary current until potential drop measured on a galvanometer reaches standard value. Numerous examples of use of instrument are described, most referring to ferrous alloys, although measurement of walls of copper boiler is referred to. Instrument has indicated local thinning of metal walls, tubing of uneven wall thickness, etc., and can be used for steel plates up to 1.25″, and iron castings up to 3″ thick. With boiler tubes, accuracy is within a few thousandths of an inch.—*I. M.*

X-Ray Control of Welded Joints in Structural Steel. Evert Lundquist. Teknisk Tidskrift, Uppl. E, (Sweden) **70:** 40 (Mar '40). In structural steel welds, skill of operator bulks large among factors of success, and is likely so to continue. Welding, owing to its many advantages, is more and more superseding riveting. Stringent regulations are now in force in most countries to ensure that on important work none but skilled welders shall be employed.

As, however, feeling of responsibility does not develop equally in all, and as continuous supervision of each worker is not possible, need has always been felt for method to test each joint. Those hitherto tried have included inspection of surface of weld, cutting out and testing sample pieces, drilling tests, and opening up with a chisel. Disadvantages of these methods are obvious, and detection by their means of a faulty spot in weld a matter of luck. Hence, they failed to give engineer that sense of perfect security after which he always strives. Introduction, therefore, of X-ray control, which without tampering in any way with structure, renders visible condition of every joint throughout its entire length, was a great step in advance. Became immediately evident that implicit reliance upon welder's skill is unwise, inasmuch as both cracks and other faults may at times develop quite without his knowledge. Already, increases of stress have been sanctioned for joints which are 100% X-ray controlled. Apparatus required is identical in principle with that in use in hospital. Perfect insulation against X-ray or high-tension current leakage is essential, as also portability. Weight is considerable, but is being reduced. Skiagrams are taken either on fluorescent screen or photographic film; defective spots show light on former, dark on latter, with which material up to 95 mm. in thickness can be successfully X-rayed with a 250-kv. apparatus, to show differences of 1-2%. Former is only suitable for steel not exceeding 12 mm. in thickness, or for light metal not exceeding 30 mm.; and as its accuracy of reading is not closer than 7%, it is not suitable for structural steel. Chief advantages of welded over riveted joint are: (1) improved distribution of stress, (2) considerable saving in weight, (3) greatly improved appearance, and (4) reduced cost of upkeep (painting, etc.). Seven good illustrations are given of X-raying in field of joints on large structures; six more of important welding details, faulty and otherwise; and six of skiagrams which reveal defects of various kinds. Design of welded joints is discussed; superiority of butt- to lap-weld, and especially from control standpoint, is upheld. Importance of certain other aspects of welding technique has been brought to light by X-ray control. Skiagrams given are worthy of study. Since lead and its compounds are highly opaque to X-rays, it is important to remember that in those cases where joint has to be painted before X-raying, pigment must be carefully excluded from region of joint. X-ray control has been found to eliminate, within a short time, many defects, of existence of which welders had been previously unaware. It stimulates them to aim at faultless work. Proper control of X-ray control itself is also important; for, if too lax, disaster may ensue; and, if too rigid, needless expense.—*Frank Hannan.*

Photomicrography at Low Cost. GLEN W. CAMPBELL. W. W. Eng. **93:** 64 (Jan. 17, '40). Description given of inexpensive means of taking microphotographs of algae. In use, eye piece of microscope removed, adapter to eliminate extraneous light slipped over drawtube and eye piece replaced. Objects to be photographed then placed in focus, camera attached to 'scope and focusing completed on ground glass of camera. "Eastman Super Sensitive Panchro Press" film found satisfactory. Good exposures obtained with 100-watt bulb in 5 sec. time. Picture with Whipple micrometer disc in place gives comparative size information. Several illustrations.—*Martin E. Flentje.*

DISTRIBUTION SYSTEMS, MAINS AND TANKS

Design of a Potable Water Distribution System. A. L. Auderut Barbeito And V. L. Inglese. Bol. Obras Sanitarias Nacion (Buenos Aires) **3:** 237 (Sept. '39). Article describes in detail steps involved in design of distribution system for town of Santa Lucia, Argentina. Design, which is presented as typical for cities of less than 10,000 pop., was made for a future pop., 25 yr. hence, of twice that. Ave. per capita consumption was fixed at 300 liters per day. Closed grid type of distribution system was selected and pipes were classified as principal, those forming frames from 2 to 3 city blocks to a side, and secondary, those used within the frames of principal pipes. Sizes of the principal pipes are the only ones determined by calculation, while the sizes of the pipes in secondary system are selected between 0.040 and 0.100 m. in diam., depending on importance of city, chem. composition of water, etc. When calculations show need for a main larger than 0.250 m., it is customary to install parallel to it a pipe of minimum diam. on which taps for house services are made. Only service connections made at time of laying mains are those for existing houses. Capacity of distribution system is designed for a max. daily consumption of 1.6 times ave. Design also allows for a minimum head at critical points of system of 4 m. more than ave. height of buildings in city. Economic reasons ordinarily limit head to that necessary to serve directly houses 3 stories high. In bldgs. of more than 3 stories, additional cost of lifting water to higher floors is up to property owners. For purpose of computation, elev. of distribution tank is taken as that of bottom of tank. In general, tanks are designed so that fluctuation in water level in them does not exceed 3 m. When topographic features make it necessary, system is divided, by means of separate layouts or of pressure regulating valves, into zones served with a head of approx. 30 m. Formulas more often used in calculation of pipe diam. are that of Lang, for diam. up to 0.50 m., and that of Levy for larger diam. Williams-Hazen formula is also used. Individual steps in calculation and numerical results obtained by two independent methods for every section of pipe in Santa Lucia distribution system are presented in tabular form. System is provided with shut-off valves at all intersections of principal pipes, and at connection ends of secondary pipes, air valves are placed at every high point situated between two lower ones in line. Fire hydrants are located with an action radius of 100 m. (without overlaping), blow-off valves are installed at lowest points in system, and public fountains are provided for supply of water to sections which do not have domestic service. Graphical methods employed for determination of distribution tank size, economical diam. of pipe used for pumping water into distribution tank, and economical height of tank are also described and illustrated.—*J. M. Sanchis.*

The T.E.M. Pressure Pipe Stopper and Connection. Anon. Wtr. and Wtr. Eng. (Br.) **42:** 16 (Jan. '40). Device is a rubber expansion stopper said to give a fluid-tight joint even if a pipe has an axial fracture of not more than 3″. Can be used in plain or bell-end pipes; can be re-used indefinitely; fits various class pipes of same diam.; avoids use of plugs and caps on temporary

work; can be inserted by unskilled labor; is quick in service; and has other advantages.—*H. E. Babbitt.*

Tests of Acid-resistant Pipe. R. D. LEITCH. Rep. U. S. Bur. Min. No. 3426. ('38). J. Soc. Chem. Ind. (Br.) No. 58. ('39). Acid-resistant pipes and pipe covering were tested by allowing mine waters to flow through them. At place where waters contained 260 p.p.m. sulfuric acid (total of 700 p.p.m. acid, including salts) pipes of alloy of copper, molybdenum,and iron, of low-copper-low-chromium steel, and chromium-plated pipe failed within 2 yr. Cast-iron pipes, plain, or coated with tar, with mixture of asphalt, sand, and cement, or with cement and sulfur, resisted a concentration of sulfuric acid of 1,000 p.p.m. (2,400 p.p.m. total acid including salts) but failed where acidity of mine waters was 4,600 p.p.m. (11,000 p.p.m. total acidity including salts); failure of pipe lined with cement and sulfur was due to attack by sulfur bacteria. Pipes which resisted attack by most acid waters included cement-lined c.i. pipes, unprotected, or treated with sodium silicate or asphalt. For waters containing more than 1% acid, most resistant pipes tested should prove satisfactory; ferrochrome pipes, or pipes lined with asphalt or impregnated fiber, or asbestos-cement pipes are also suggested as suitable for very high concentrations of acid.—*W. P. R.*

The Utilization of Bitumens in the Construction of Water Pipes and in Irrigation Projects. L. G. DEMIDOV AND N. I. ZNAMENSKII. Vodosnabzhenie i Sanit. Tekh. (U.S.S.R.) **3:** 62 ('39) *and* Khim. Referat. Zhur. (U.S.S.R.) **7:** 90 ('39). Station for complete biol. purification of water with asphalt-concrete foundation construction is described. Lab. expts. showed that biol. purification of water in aeration tanks covered with petroleum bitumens is same as that in tanks not covered with bitumens. Asphalt-concrete can be used for sloping sanitary-technical structures in rock and dense clay foundations in absence of ground waters and for stationary horizontal bottoms. Asphalt solns. can be used for water-isolating layers of concrete reservoir bottoms and for floors. Pure bitumen can be used as plastering material for various reinforced concrete and analogous structures.—*C. A.*

Asbestos-Cement Water Pipe to be Coated. ANON. N. H. Health News. **17:** 8: 12 (Aug. '39). Use of asbestos-cement pipe for public water supply mains is increasing. Because of tendency of soft N. H. waters to act upon such pipes in some degree, it has been deemed advisable to require provision of a durable coating. Mfrs. of this form of pipe have been notified no proposals for installations involving mains or transmission lines of asbestos-cement composition will be approved unless interior wall of said pipe is uniformly and thoroughly coated with bitumastic or with similar coating equally durable and satisfactory in character.—*P. H. E. A.*

Re-enforced Lead Pipe for Drinking Water Supply of a Water Sport Center. J. A. DEGRAFF. Water (Neth.) **24:** 57 (Apr. '40). Roads in which water mains were placed consist of peat and cinders. Analyses indicated that eternit pipes,

covered with bitumen were best. At bends, cast-iron pipe with a few mm. layer of asphalt were used. Several canals, one 235′ wide, with peaty ooze of unknown depth, had to be crossed, requiring special solution. To prevent costly caisson work and pile driving, lead pipe of 50 mm. diam. surrounded by galvanized netting were lowered from flat boats in duplicate. Construction of pipe: lead wall 7.5 mm., 4 layers of prepared paper, 1 layer flat wire 2.5 mm. and a layer of jute soaked in bitumen. About 1,050′ was used. This type of pipe allows uneven settling and stretch without leaks; boat hooks do no harm. Pipe was rolled on drums and placed similar to electric cable. Connection with the mains by means of iron sleeve clamped and bolted.—*Willem Rudolfs.*

Copper and Tinned Copper Piping in Water Practice. L. H. Lourve Kooijmans. Water (Neth.) **24:** 29 & 37 (Feb. 23, Mar. 8, '39). Experiments with test installations in various places. Object, solution of copper: (1) after deacidification with marble, (2) with various types of water, (3) in distribution systems, (4) in houses connected at various places in the distribution system. In all cases, with water of different chem. composition, copper piping could be allowed; one case with strongly aggressive water copper solutions was dangerous. Concerned a cloister with own water supply obtained from bricked shallow wells, cold water passing through tinned lead pipes and warm water through copper pipes. After 7 yr. leaks occurred in copper pipes. Water had low temporary hardness and considerable permanent hardness. Two cases where rules of standardization committee were not followed. Composition of one water could not be properly classified (contained: 9.9 p.p.m. O_2 and 1.5, CO_2, pH, 7.82, temporary hardness, 30 p.p.m., bicarbonates, 41); high O_2 and low mineral content considered cause of corrosion of copper. Another water (bicarbonates, 345, CO_2, 16, O_2, 6–7, temporary hardness, 287 p.p.m.) corroded copper piping (connected by solder fittings) to extent of green-blue film on top of water. Water, from various sections of system, in contact for 20 hr. showed from 3.5 to 7.9 p.p.m. Cu. Expts. with different types of piping showed during 1½ years Cu varying from 3.5 to 6.5 p.p.m. Various waters dissolve Cu at much higher rate than expected on basis of committee report. Reduction of organic material (with activated carbon) had no effect on corrosiveness. Expts. show that water highly corrosive to copper pipes could be distributed in tinned copper pipe, provided tin amounted to 30 grams per sq. m., Cu in solution after ½ hr. contact with ammonium persulfate solution is not more than 0.5 p.p.m. and maximum lead content of tinning is 0.5%. Covering should be pore-free. Commercially tinned copper piping may contain 15 to 25% lead in tin layer.—*Willem Rudolfs.*

Cast-Iron Pipe in Long Time Service. Lester Long. Southwest W. W. J. **22:** 13 ('40). History of pipe is history of civilization. Brief interesting historical survey of use of cast-iron pipe since its probable first manufacture about 1313 A.D. Short discussion of early preparation of cast iron in China and use of iron pipe in Europe. Describes installation and present condition of cast-iron pipe in use from 47 to 112 yr. in 38 cities in U. S.; oldest pipe now in service being in Philadelphia.—*O. M. Smith.*

Water Main Construction Pollutes the Supply. ANON. Public Works **70:** 8: 26 (Aug. '39). Mississippi R. water at St. Paul is free of contamination as it leaves treatment plant, but during summer months infected areas are found in distribution system where new construction or repairs have been undertaken. Liquid chlorine is used in feeder mains supplying contaminated areas. Carelessness in main construction resulted in such pollution that ave. index of 132 samples in July was almost as high as unfiltered coagulation basin effluent.—*P. H. E. A.*

Experiences at Akron with Rubber Packing to Replace Jute and Hemp in Laying Cast-Iron Water Mains. W. R. LADUE. Ohio Conf. Water Purification, 19th Ann. Rept. p. 87 ('39). Jute and hemp are capable of sustaining growth of coliform bacteria and, as result, new mains sometimes showing contamination for several months despite attempts to sterilize them with chlorine compounds. Efforts to sterilize jute and hemp prior to use have met with varying degrees of success: sterilization with mercuric chloride is probably most effective. A new rubber packing, obtainable in 2 forms—thick-walled tubing and solid wedge shaped—has apparently solved difficulty in Akron. About 1,000′ of main has been laid using this packing and, after sterilizing with hypochlorite, bacterial count has never exceeded 15 per ml. Early leakage is much lower than with other packings; ranging from 60 to 80% of permissible 100 gal. per mi. per in. per day. Pipe layers like rubber packing because it is easy to use, centering is almost automatic, yarning effort is reduced, and loss of joint material past the ring is practically eliminated. In regard to latter, tubing has advantage of accommodating itself to surface irregularities in pipe and to compression required in laying pipe in curves.—*R. E. Thompson.*

Experience with Various Kinds of Pipe and Jointing Material. ASHLEY G. CLASSEN. Tex. W. W. Short School. **21:** 43 ('39). 8 yr. of experience in using neat portland cement as jointing material for bell and spigot c.i. pipe has been very satisfactory and gratifying. In certain areas in El Paso iron seems to be literally dissolved out of c.i. or steel pipe by something in soil. Counteracted by surrounding pipe with 6″ of mixture of 1 part lime to 8–10 parts sand by vol. Failure due to corrosion of c.i. pipe is more dangerous and disastrous than failure with steel pipe because fractures occur suddenly and completely, releasing large quantities of water.—*O. M. Smith.*

Pipe Cleaning Experiences at Königsberg. GERHARD SATTLER. Gas u. Wasser. **83:** 221 (May 11, '40). Distribution system was started 1872. Work was done without much care, and leakage was great. First ground water supply rich in iron was used. This caused growth of iron organisms. Then surface water after slow sand filtration was used. Water was soft and rich in CO_2 and caused much corrosion. Since '28, filtration plant using chem. coagulation and de-acidification has been in operation. To avoid complaints, decided to clean some of pipes from old growth and corrosion. Pipes of 6″ and larger were cleaned with turbine apparatus which moves and rotates by water pressure. Head of 33′ required for 10″ pipes and of 50′ for 6″ pipe.

Cleaned material is floated out ahead of cleaner. Smaller pipes cleaned with scraper pulled through pipes against current. Distances averaging 450′ could then be cleaned in one operation. Pipe cleaning had to be done in spring, as summer peak loads did not allow taking part system out of operation and cold climate did not allow such operation in winter and autumn. Material removed was practically free of organic matter.—*Max Suter.*

Frozen Water Mains and Service Pipes—A Solution. Alan Boothman. Surveyor (Br.) **97:** 207 (Mar. 1, '40). Ministry of Health requires that water mains be laid at depth of not less than 3′. In thawing services in localities where a.c. current is available small transformer steps voltage down to 10 to 20 and closed circuit is formed by connections inside 2 houses served by same main. Generally no regulating resistance is called for, and the higher the amperage, within limits, of course, the quicker the thaw will be achieved. Where connections are not possible in adjoining houses one of secondary leads should be attached to stop-cock ferrule coupled to water main. Transformer forming component part of well-known electric stove has been used without difficulty and without change. Stove was carried in water works van and lead from power-point brought into roadway, one of secondary leads being taken back into house. To thaw a main, equipment should include motor-driven generator to develop 350 amp. between 50 and 100 volts. Current is to be applied, with variable resistance, through large copper clamps at two points on frozen main.—*H. E. Babbitt.*

Electrical Thawing of Water Supply Pipes. C. H. George. Wtr. & Wtr. Eng. (Br.) **42:** 188 (May '40). Welding transformer was borrowed by water dept. of Birmingham in Feb. '40. Transformer, of 15 k.v.a. was normally worked on 400 volts, 50 cycles, 3-phase, a.c., but to suit voltage obtainable on private services it was necessary to alter primary tappings to take 230 volts, 50 cycles, single-phase current. First working test was carried out on a ¾″ service which was frozen from main to house, a total length of 44 yd. Water began to rise in stop-tap box in 12 min. In 15 min. it was flowing freely over top of box. Tap was then closed and in a total time of 20 min., water was flowing freely from kitchen tap. In another 5 min. it was pouring through first floor ceiling from an unsuspected internal burst. One unit of current was consumed. Longest thawing time taken was 2 hr. and 45 min. For 9 days, transformer was in continuous use and proved itself uniformly successful over a wide variety of jobs. Ave. number of services thawed was 5 per day. Welding generators are practically always d.c. machines and question arises as to whether d.c. would perform quite so well as a.c., since reversal of polarity with a.c. may have advantages in breaking down ice.—*H. E. Babbitt.*

Brackets Aid Pipe Line Servicing. Elton Sterrett. Eng. News-Rec. **124:** 531 (Apr. 11, '40). Servicing of pipe line carried on A-frames across swale severely scoured by flash floods was facilitated by welding brackets to frames 3′ below saddles. By setting brackets almost perpendicular to leg of frame, retainers are not required to hold planks in position during servicing operations.—*R. E. Thompson.*

Maintenance and Repair Trucks Show New Features. ANON. W. W. Eng. **93:** 226 (Feb. 28, '40). Description given of emergency and repair truck of Queens Borough Maintenance branch of N. Y. City Water Dept. Among features is hydraulic elevator tail gate unit (cost approx. $435), 105 cu.ft. per min. at 100 lb., air compressor, 2 air driven water pumps with capac. of 200 g.p.m. at 20′ each, lighting generator, valve operating device, etc. Total cost of truck $5,960, weight, 18,000 lb.—*Martin E. Flentje.*

Valve-Operating Truck. J. C. DETWEILER. Eng. News-Rec. **124:** 532 (Apr. 11, '40). Brief illustrated description of "lawn mule" used by Metropolitan Utilities District, Omaha, Neb., for serving maintenance crews, pulling gang mowers, and operating valves on station grounds. Truck consists of short-coupled Ford Model-A chassis with small hand-dump body and valve-operating equipment mounted on side. Three regular-service trucks are also equipped with valve-operating mechanisms.—*R. E. Thompson.*

Leak Detection and Leak Surveys. K. F. HOEFLE. Tex. W. W. Short School. **21:** 31 ('39). City of Dallas has instrument consisting essentially of pick-up microphone and receiving set containing tuning coil, meters and amplifiers. 6-v. storage battery and converter supply current. Set is tuned to frequency of leak vibrations and is calibrated so that amplitude of leak signal can be measured. Second reading at another point then tells operator, by observing increase or decrease of amplitude, whether he has moved toward or away from it. Becomes simple matter to go directly to leak. No knowledge of principles of radio is required to operate instrument. Percentage of dry holes dug has dropped to less than 4%. To be effective leak survey must be systematic and complete. During 6 mo. of operation 235 mi. of main were listed at cost of $5.04 per mi. and 264 leaks discovered resulting in a saving of 1,425,000 g.p.d.—*O. M. Smith.*

A Discussion of Water Main Leakage. D. W. JOHNSON. Tex. W. W. Short School. **21:** 34 ('39). 8 surveys indicate that leakage found on c.i. mains is not as large as from meters, services and other appurtenances attached to mains. Vary respectively: mains, 0.3 to 1.3%, meters, 4.2 to 4.5% and services 2.3 to 5.2%.—*O. M. Smith.*

The Useful Life of Iron and Steel Standpipes. CHARLES W. SHERMAN, J. N. E. W. W. A. **54:** 149 (Jun. '40). Reports study showing actual service life of number of standpipes which have been abandoned because of failure, deterioration, or inadequacy, and actual present age of those still in use ('39). Data obtained on 111 standpipes in the 6 states (Me., N. H., R. I., Conn., Mass. and N. Y.). Ave. life of all, assuming additional life of 7 yr. for all standpipes 35 yr. or more old, 45 yr.; ave. life of those abandoned 32 yr.; range, 2 to 56 yr.; number abandoned, 44; number standpipes still in use after 35 yr. or more, 67; ave. age, 47 yr.; max. age, 58 yr.—*Martin E. Flentje.*

The Blue Ridge Tank of Indianapolis. MILLER HAMILTON. W. W. and Sew. **86:** 431 (Nov. '39). Elevated storage was necessitated by growth of new

section of city. Tank is spheroidal with radial-cone bottom, streamlined, welded, and landscaped. Capacity is 1.5 mil. gal. 16 supporting columns are tubular, one serves as access tube, another as riser pipe. Information of altitude control, recording, and foundation conditions is given. Corrosion protection inside tank is cathodic. Surfaces exposed to water are unpainted. —*H. E. Hudson Jr.*

Santa Fe Erects All-Welded Steel Tank. ANON. Railway Eng. and Main. **36:** 1: 30 (Jan. '40). The Atchison, Topeka and Santa Fe R. R. recently completed the erection of a 24′ diam. by 60′ high all-welded steel standpipe tank for water storage at Newton, Kans. The 8 shell courses were butt welded with vertical seams staggered and connected to bottom plates which projected 2″ beyond exterior of shell, with a fillet weld. A total of 1,108 lin. ft. of welding was required.—*R. C. Bardwell.*

Making a Landmark of an Elevated Tank. EUGENE CLUTE. Am. City, **55:** 2: 44 (Feb. '40). Beauty of architecture and economy has been combined in enclosing old elevated water tank at Darien, Conn., with 2″ thick walls of concrete reinforced with light vertical ribs and horizontal bands of steel with wire mesh stiffened by small reinforcing rods. Tank as it looks now might well be monumental landmark, adding much to attractiveness of community. Believed method used here was tried out for first time in this type of construction. Despite thinness of enclosing walls (an important factor in saving of material), structure has proven ability to withstand severe storms. Would seem the community has benefitted by this transformation in every way, even to no cost whatever, since the water co. did the work gratis.—*Arthur P. Miller.*

The Contest on Elevated Water Tanks Organized by the Committee on Hygiene and Water. JACQUES HÉRISSAY. L'Eau (Fr.) **32:** 49 (May '39). To remedy marring of French countryside by ugly elevated water storage tanks, Committee on Hygiene and Water organized contest to which numerous architects and engineers responded. Two aesthetic tendencies are definitely shown, traditional and modern. In awards, jury has rightly considered two solutions equally acceptable and suitable, but in each region in France, style chosen should harmonize with local traditions and customs. Remains of old Roman aqueducts are noted as illustration of beauty in water works construction. Hoped that municipalities building tanks will benefit by new ideas presented. Certain designs submitted would be suitable in any location. **Results and Information on the Contest on Elevated Water Tanks.** L. DESCROIX: *Ibid.* **32:** 51 (May '39). Origin of term "chateaux-d'eau" to designate an elevated water tank is ascribed to pumping station built in Paris in 1606, similar project in Strasbourg in 1765 or to monumental Paris fountain of 1810. In present contest, term means res. with pumps, if needed, and contest was limited to projects for small towns or rural communities. Open to French architects or French engineers specializing in water supply. Entries were to be technically practical and designed to beautify town or rural site and harmonize

with surroundings. Res. to be of 200–350 cu. m. capacity and 15–20 m. high. Entrants numbered 150 and submitted 170 projects. In author's opinion, res. should be circular and supported by circular or regular polygonal tower. Unaesthetic mushroom type of reservoir should be avoided; cylinder or cone is acceptable. Stairway should be spiral and enclosed. Though squat appearance should be avoided, tank should have water depth of not over 4 to 5 m. for capacity designated to avoid large pressure difference when tank is full or empty and to lower pumping costs. First prizes were awarded to: (1) an entry featuring a cylindrical tower supporting a cylindrical tank of somewhat larger diam. crowned by a conical roof, the whole resembling a pigeon house characteristic of region, and having a low covered porch sheltering adjacent wells; (2) a decorative project centered on a formally laid-out circular terrace, with a circular tank with flat top relieved by a circular dais and mounted on 6 tall square peripheral pillars. Spiral service stairway and water pipes are concealed in a central grill-work pillar. Pump room if needed is located underground. Other prize-winners include: a cylindrical tower and tank with ornamental ribs serving as supports, a tower designed to harmonize with an old church immediately adjacent, another designed for a public garden in Provence with cylindrical tank slightly set back over tall cylindrical base, and ornamented with horizontal rows of overlapping tiles and a small balcony. Many entries substituted a circular or polygonal collonade for unbroken supporting tower wall with good effect, though supply pipes cannot be dissimulated and access to res. must be allowed. In several entries this was solved by substituting for central service column a similar column reinforcing outside of one of the peripheral supports. Numerous tanks are double-walled for insulation. Worst architectural error is attempting to camouflage res. as medieval gate, feudal tower, astronomical observatory, windmill, etc. Simplicity is mother of beauty and excessive decoration is to be deplored. Technically, round towers are preferable to square ones, and shallow to deep. Access to res. must be easy and safe. Conduits must be protected against freezing. Res. on hills should be subterranean instead of elevated for economic and aesthetic reasons and to minimize use as target or bench-mark for airplanes. Interest in beautiful elevated water tanks aroused by this competition should have widespread effect. 24 figures of prize-winning designs. —*Selma Gottlieb.*

Two Water Towers in the Province of Groningen. H. F. MERTENS. Water (Neth.) **24:** 13 (Jan. '40). Appearance of utility buildings is strongly influenced by technical considerations and usage. Expression of usage is especially emphasized in water towers. Practical considerations require a rather squat structure. Underpinning of res. may be open, but when enclosed can be used for other purposes. From architectural viewpoint shell, covering various functions, should express use. Water tower at Stadskanaal under a surface layer of peaty soil 1.8 to 2.0 meters thick; a layer of sand (12 m. or more) supports a steel foundation. Soil analyses and friction coefficient determinations indicated that a pressure of 2.1 kg./cm.^{2} was safe. Not necessary to divide tank with a capac. of 900 cu. m. for cleaning purposes. Tank is carried by 1 center and 8 outer columns; floors serving for rigidity of system. Bottom

rests immediately on 9 columns, while walls of tank aid for covering. Reinforced concrete res. and brick shaft are entirely free, affecting each other only horizontally through floors. Shell is covered with brick, resting on shelf of reinforced concrete, but free of concrete res. Columns under res. floor are placed in such a way that with res. full, pressure moment is abrogated by sum of moment of water pressure produced by horizontal pressure against res. walls and moment caused by weight of floor of masonry shell resting on shelf. Tower stands on 8-sided foundation plate, surrounded by a ring on which 8 columns stand. Ring serves to prevent irregular settling. Concrete mixture 1–2 sand. After hardening, twice sprayed with bitumen; scoured immediately. Shaft is one brick thick covered inside with cement. Water tower at Oude Pekela placed about 40 m. from road, with pond in front used for water storage when tank is emptied. Tower is 8-pointed star consisting of two crossed squares with a beam of 36.7′ and 39′ at foot. Shell of the res. has inside diam. of 46.5′ and an effective capac. of 35,300 cu.ft. Tower is of steel; soil is sand with thin sheets of clay; ave. ground pressure with filled res. 2.15 kg./cm.^{2}. Construction is same as for Stads Kanaal. Construction required about 1 yr.—*Willem Rudolfs.*

TUNNELS AND AQUEDUCTS

Delaware Aqueduct. *II. Routing the Tunnel.* ANON. Eng. News-Rec. **124:** 584 (Apr. 25, '40). (First article of this series—A Billion Gallons Not Enough—was abstracted in August, 1940, Issue (Jour. A. W. W. A. **32:** 1413).) Delaware system will comprise 3 aqueducts: main Delaware aqueduct, from Rondout storage res. at Lackawack in Catskill Mountains to Hill View distr. res. at northerly limits of city; and 2 feeders, 26 and 6 mi. long, respectively, to deliver water from East Delaware res. and from Neversink res. into Rondout res. All 3 aqueducts will consist wholly of concrete-lined tunnels in rock. Feeders will be grade tunnels and main aqueduct will be pressure tunnel, circular in section and lined with concrete throughout its 85-mi. length. Together with southern extension, in service since '36 as auxiliary distributor for Catskill water, it will make continuous deep pressure tunnel in rock 105 mi. long. Total length of tunnels in system will be 137 mi. Main tunnel will be 300–1000′ below general elev. of ground. Internal pressure exceeds 500 lb. per sq.in. in places. Tunnel is divided into 6 sections, connected through gate houses at tops of terminal shafts. Conditions determining route are detailed. Plan and profile are illustrated. *III. Designing the Aqueduct. Ibid.* **124:** 656 (May 9, '40). Conditions governing size of tunnels and shafts and equipment in latter are described. Aqueduct is designed throughout for capacity in excess of estimated safe yield. In tunnels, min. thickness of concrete to "A line," within which no rock is permitted to project, is 10–14″. In computing thickness of lining, effective thickness is taken to "C line," that is, 5″ outside "A line." With current excavation methods, there is only small percentage of rock between these lines. Thicknesses to "C line" were computed by Lamé formula for stress in thick hollow cylinder, assuming external load to full ground water head for general elev. of overlying ground. Limitations of this formula are recognized but more refined analysis does not seem warranted. Shafts are lined with concrete as they are sunk. In most shafts,

7–10 galvanized steel pipes, 1–6″ in diam., have been built into lining to carry compressed air, water supply and electric conduits. These will be filled with concrete on completion. This type of construction is fireproof, completely protects vital pipes and leaves shaft unobstructed. In tunnels, each heading will be completely excavated before lining. Steel supports are used. Timber, other than in posts, is permitted only sparingly, and all timber possible must be removed prior to lining. Local conditions precluded surface magazines in several locations. At such places, underground magazines have been excavated from tunnel at safe distance from shaft. They are fitted with massive doors that will close automatically in event of explosion and are of such volume that explosion of entire permissible content of 3,000 lb. of dynamite will not generate destructive pressure. Reliance is placed on surrounding rock for resisting internal pressure. All voids outside lining which cannot be filled with concrete will be grouted under final pressures of 300–1,000 lb. per sq. in. *IV. Access to the Aqueduct. Ibid.* **124:** 797 (June 6, '40). Riser shafts (9) provide means of drawing off water for other communities and drainage shafts (3) facilitate prompt unwatering. Risers terminate in bronze cross of shaft cap anchored to steel riser and shaft concrete; and each outlet from cap is closed by bronze guard valve, beyond which iron or steel valve will be placed for ordinary operation. Each riser will also be provided with bronze needle valve which will close automatically in event of break in trunk main. Capacity of sections served by drainage shafts varies from 164 to 232 mil. gal. and static lift from 320′ to 680′. Shafts are equipped with permanent guides, cages and hoists for safe convenient access. There will be 3 main horizontal electrically-driven centrifugal pumps at 2 shafts and 4 at other, each with capacity of 4,500 g.p.m. In unwatering, 600-g.p.m. sinking pump of multi-stage centrifugal deep-well type mounted in cage will lower water in shaft to enable installation of main pumps in pump chamber. It is expected that it will require about 2 weeks to unwater any of tunnel sections after main pumps are connected. *V. Controlling the Flow. Ibid.* **125:** 109 (July 18, '40). In each main division, Rondout-West Branch, West Branch-Kensico, and Kensico-Hill View tunnels, rate of flow will be controlled at inlet end. Three conditions had to be met in design: (1) dissipation of energy without cavitation and erosion; (2) limiting of surge; and (3) prevention of air entrainment. When flow is small there will be much energy to dissipate. High heads in first 2 tunnels impose further condition that control valves be either wide open or closed in order to prevent cavitation and erosion, necessitating division of flow through parallel valves. Entrained air would accumulate in upper parts of tunnels and eventually escape in huge bubbles up open shafts, blowing up great masses of water. Control works are radically different in each case but are designed on following general principles. Surge will be restricted by: (1) limiting speed of changes in rate of discharge into tunnel by subdividing flow through parallel valves or gates and by limiting speed of valve and gate movement; (2) providing surge chamber at shaft into which valves or gates discharge, through enlargement of shaft or otherwise; and (3) provision of overflows at tops of uptake shafts and downtake shaft of West Branch-Kensico tunnel. Entrainment of air will be limited by: (1) locating point of discharge into downtake shaft below lowest operating tailwater level so that discharge point will always be submerged;

(2) enlargement of downtake shaft at point of entrance to afford low downward velocity of water and permit escape of air; and (3) preventing renewal of supply of air to any place where air might be entrained. Excess energy will be dissipated by different methods depending upon local conditions. Details of 3 effluent works are given. *VI. Driving 85 Miles of Tunnel. Ibid.* **125:** 288 (Aug. 29, '40). Ten contractors are driving 11 tunnel sections totaling 83.8 mi. for total of $140,109,135. First mi. of tunnel at Rondout Res. intake is part of Merriman Dam contract. Tunnel is of circular section, in 3 sizes: 43.1 mi. of 13.5′ finished diam. requiring excavated section of about 18′; 27.1 mi. of 15′ and about 20′, respectively; and 13.6 mi. of 19.5′ and about 24′, respectively. Drilling and blasting, mucking, and timbering are described. Other functional operations will be dealt with later. For first time on large tunnel project, automatic feed drifter drills are being used throughout. Another feature common to all sections is carrying of high-tension current at 2,300 v. into tunnel, reducing it to desired voltage with underground portable transformers. Gelatin dynamite is used in 40 and 60 strengths and every known safety precaution is observed. About $\frac{2}{3}$ of entire length of tunnel requires ground support, all of which is of steel. Shotcrete supplements the support and replaces it in some instances.—*R. E. Thompson.*

Metropolitan Boston's New Water Supply System. W. R. Brend. Can. Engr. **77:** 22: 9 (Nov. 28, '39). Brief details given of steel-concrete pipe being supplied by Lock Joint Pipe Co. for 10-mi. pipeline under construction. Fabrication procedure consists of welding steel shell, with spigot ring on one end and bell ring on other, winding 2 cages of reinforcing wire around exterior and covering with concrete inside and out. Pipe is made in 3 diam., 84″, 138″ and 150″. Shell thickness varies from 10 gage to $\frac{1}{4}$″, reinforcing wire from $\frac{5}{8}$ to 1″, concrete thickness from 8″ to 12″ and sections weigh up to 50 tons each. Wedge-shaped recess at joint is filled with fibre-filled lead gasket and calked after pipe is laid. Internal pressure tightens gasket and joint will withstand pressures of 50–150 lb. Tractor-trailer units are used to transport sections to site.—*R. E. Thompson.*

Concrete Pipe Line with Two Tunnels. Anon. Am. City. **55:** 3: 53 (Mar. '40). A 24-mi. pipe line is part of $4,000,000 water-supply system under construction for Bethlehem, Pa. System includes clay core dam 135′ high and 1,200′ long at crest, having storage capac. for 16 m.g.d. min. supply and reserve for 250 days. Normal capac. of pipe line is 18 m.g.d. Supply will be obtained by gravity from Wild Creek in Pocono Mts. No booster pumps are necessary, normal flow being entirely adequate. 2 tunnels—one 5,800′ and one 4,700′ long—were used to pass 2 mountain ridges. On surface varied laying conditions were encountered, from low swampy land to extensive rock and shale formations requiring considerable blasting. In laying pipe along main highways, traffic interruptions held to a min. by excavating just enough trench for one section of pipe at a time. Immediately pipe fitted into place, trench was backfilled and trench started for another section. The 21 mi. of reinforced concrete pressure pipe was made in 3 sizes: 24″, 30″ and 36″. Joint rings used, bell-and-spigot type, are self-centering when laid, and permit expansion and

contraction. Rubber gaskets are used for sealing the 24″ and 30″ pipes; and a fiber filled lead gasket, calked from inside, is used for the 36″ pipe. Project was financed by bond issue totaling 55% of entire cost; remaining 45% being furnished by federal work relief grants.—*Arthur P. Miller.*

Siphon Self-Supporting in Long Spans. P. J. BIER. Eng. News-Rec. **124:** 852 (Jun. 20, '40). Shoshone R. siphon, part of 28-mi. canal of Shoshone irrigation project, consists of 867′ monolithically-placed concrete pipe and 856′ of welded steel pipe. Siphon, which connects 2 concrete-lined tunnels, is 10′ 3″ in diam., and has capacity of 914 c.f.s. Max. static head is 155′. Central span of Shoshone R. canyon crossing, 150′ long, is believed to be world's largest unsupported pipe span. Bending and shear deflection at center of span was computed at 1½″ with pipe full of water. Camber equal to computed deflection was provided so that pipe would be level when full. Expansion joints, connecting river crossing spans with remainder of siphon, are of special double-acting type, permitting both longitudinal and lateral movement. All welded joints in river crossing were radiographed. On completion, no leaks were found under test pressure of 137 lb. per sq. in. and central span deflected to within $\frac{1}{16}$″ of horizontal under water load. Details given of design and erection of river crossing. Cost of siphon was $271,000.—*R. E. Thompson.*

Proposed New Intake for Montreal. C. J. DESBAILLETS. Can. Eng. **78:** 1: 9 (Jan. '40). Water supply of Montreal is drawn from St. Lawrence R. about 5 mi. upstream from water works. Intake consists of four 6′ pipes (2 extending 1,100′ into river and two 450′) buried in river bottom and connected to intake gatehouse from which water flows to filter plant through open canal. Also a lateral conduit under canal banks capable of handling part of consumption. Works were built in '13–'14, when consumption was half that of present time. Ice troubles have been serious during past 5–6 yr., owing to necessity of operating much above designed rate. Increased pop. has also given rise to greater pollution near river shore. Tenders were received recently on construction of new intake to consist of six 7′ pipes extending about 2,000′ from shore to point where pollution is min. To minimize ice difficulties, inlet will consist of series of intake manifolds designed to give equal entrance-velocities at all points. New gate-house is provided also, designed to permit isolation of individual pipes to enable flow-reversal for ice removal. Capac. will be 300 m.g.d. Sketches show plan of new works and details of intake manifolds and joints.—*R. E. Thompson.*

A Quarter Century of Aqueduct Maintenance. ANON. Eng. News-Rec. **124:** 784 (June 6, '40). Los Angeles' Owens Valley aqueduct has never failed, during 27 yr. of operation, to deliver water when needed. Aqueduct, some 240 mi. long, was completed in '13 at cost of $24,500,000. It is made up of 24 mi. of unlined canal, 37 mi. lined canal, 98 mi. covered conduit, 53 mi. lined tunnel, 13 mi. of steel and concrete pressure pipe, and 8 mi. of reservoirs. Latter permit shutdowns for repairs. Capacity is 500 cu.ft. per sec. Temp. along line varies from —10 to 120°F. Detailed records are made of all in-

spections. Handful of cement plaster is placed on each crack in tunnels and decisions on important repair work are often based on effect of cracking on these "pats," as recorded in logs. Dragline has replaced old dipper dredge for removing canal deposits. Weeds and willows are removed with aid of pontoon barge. Use of distillate-type oil for killing vegetation was abandoned because it killed roots, which perform valuable function in retaining bank slopes. Eel grass is cut with 15′ sharpened bar towed behind barge, copper sulfate having been found ineffective. Bentonite is used to seal canal following cleaning. Concrete in lined canals is repaired by patching or applying shotcrete, $\frac{1}{2}$-$\frac{3}{4}$″ thick. Use of copper sulfate has not been successful in controlling algae growths in canals—allowing canal to remain dry 3–4 days is more effective. Algae growths develop on new concrete more than on old. Tunnels are inspected twice each yr. Steel siphons present more maintenance problems than other types of construction. Troubles resulting from "breathing" have been most persistent and as result all $\frac{1}{4}$″ and $\frac{5}{16}$″ metal is being replaced by $\frac{3}{8}$″. Pipes made of thin plate also have tendency to flatten on emptying. On some siphons, gravel travels up downstream leg to level where forces of water velocity and gravity are equal. Sliding of gravel backward and forward wears metal at this point. It has been noted that $\frac{1}{4}$ circumference of pipe may be safely cradled in concrete piers—any concrete above limits of 90° subtended angle is likely to be sheared off.—*R. E. Thompson.*

Forty Years of Service for Steel Pipe Line of Seattle. R. H. Thompson. W. Cons. News. **14:** 405 (Dec. '39). Cedar R. recommended for city water supply in 1881, not begun however until '99; estimated cost was $1,250,000. 42″ wood-stave pipe used up to heads of 200′, riveted steel for higher heads. Wood stave pipe used for economy, required fairly long service life; repairs and replacements made in '09, '11, '12 and '16, all remaining replaced in '34. Of original steel pipe 6,550′ of $\frac{7}{16}$″ thickness, 2,150′ of $\frac{3}{8}$″, 8,450′ of $\frac{5}{16}$″ and 16,950′ of $\frac{1}{4}$″. Some difficulty experienced with electrolysis, 8,982′ of pipe taken up and re-used with little repair. One section of 6,545′ has had but one leak requiring repair in the 40 yr. of service. In general, steel line except for portions affected by electrolysis still in good condition.—*Martin E. Flentje.*

Plugs for Aqueduct Testing Formed from Steel Plates. Stanley M. Dore. Eng. News-Rec. **124:** 330 (Feb. 29, '40). Brief illustrated description of rolled steel bulkheads being employed to close off and take hydrostatic thrust in sections of new Boston pressure aqueduct during watertightness tests. Structural steel and timber bulkheads are customarily used in aqueducts of smaller diam. Aqueduct, 17.5 mi. long, is divided into 6 sections, each being constructed under separate contract. One section is in tunnel and other 5 cut-and-cover aqueducts built of pre-cast reinforced concrete steel-cylinder pressure pipe, up to 12.5 diam. Specifications require that leakage under full working hydrostatic head shall not exceed 75 gal. per in. internal diam. per mi. per day.—*R. E. Thompson.*